

# Control ENGINEERING

INSTRUMENTATION AND CONTROL SYSTEMS

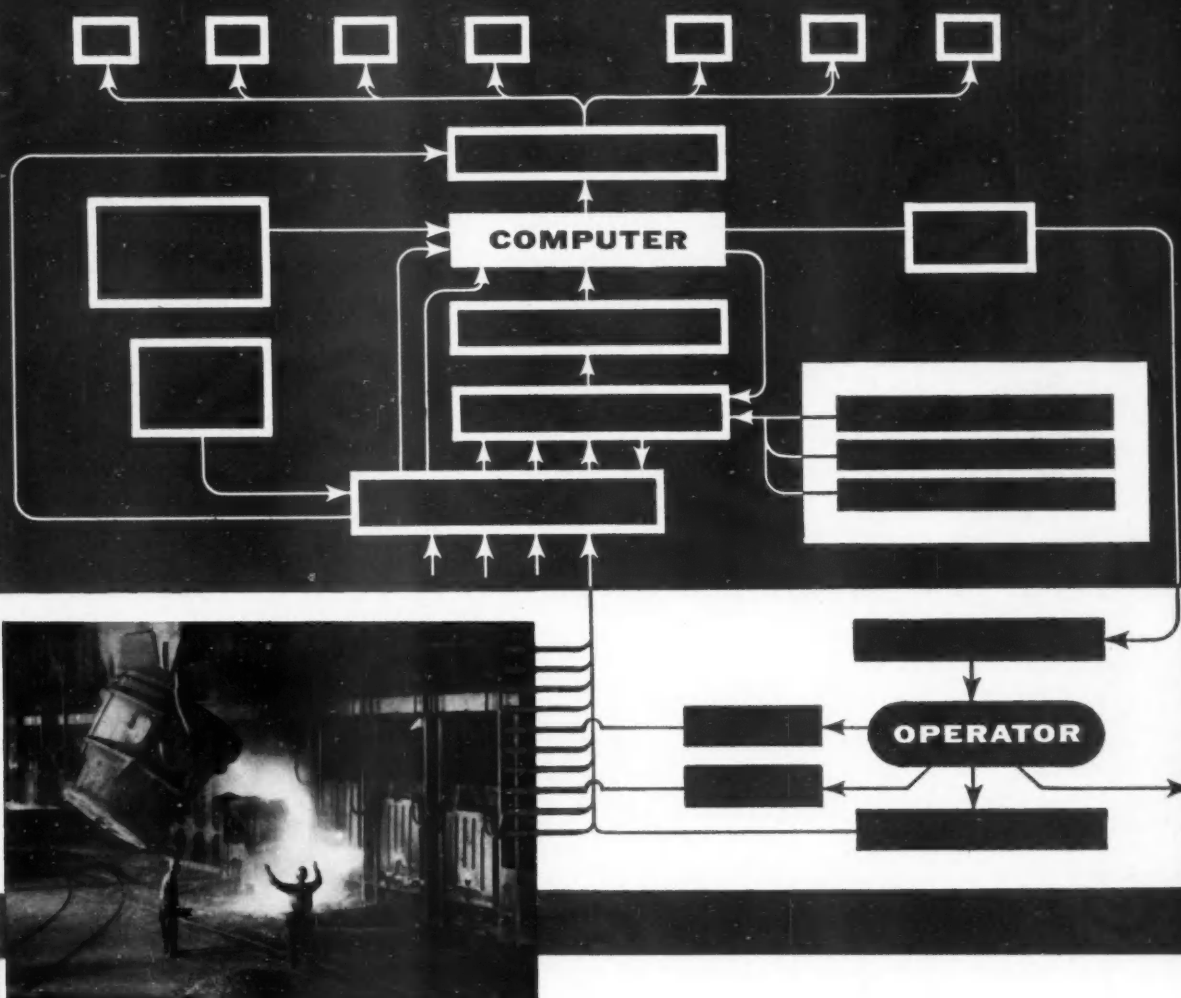
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75 Cents

AUGUST 1959

## Digital Computer Programs

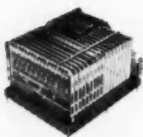
### Open-Hearth Operations



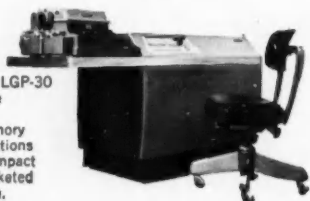
*Also in this issue*

Specifications Link User and Maker  
Comparators in Automatic Evaluation Systems  
Punched Tape Controls London Trains

In the missile: small transistorized general purpose digital computer for flight control and guidance. 2000-word magnetic-drum memory.



On the ground: LGP-30 general purpose computer with 4096-word memory for such applications as design and impact prediction. Marketed by Royal McBee.

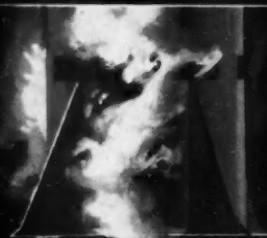


*At every stage, the success of a missile program depends upon a computer. Librascope computers, components, instruments and systems give right answers from original concept to final evaluation.*

**THE FIRST STAGE:** Workable designs. **SECOND STAGE:** Trajectory and engineering computations required long before the launching. **THIRD STAGE:** Control, guidance; impact prediction. **FOURTH STAGE:** Data reduction and analysis. ■ Recognizing still a fifth stage, Librascope determines reliability in the lab. Environmental tests check equipment for temperature, shock, vibration, pressure and other "real" conditions likely to affect performance. Only positive answers will release Librascope equipment for field use.

# MISSILE COMPUTERS

right  
answers  
when  
you need  
them!



*For information on career opportunities at Librascope, write Glen Seltzer, Employment Manager.*

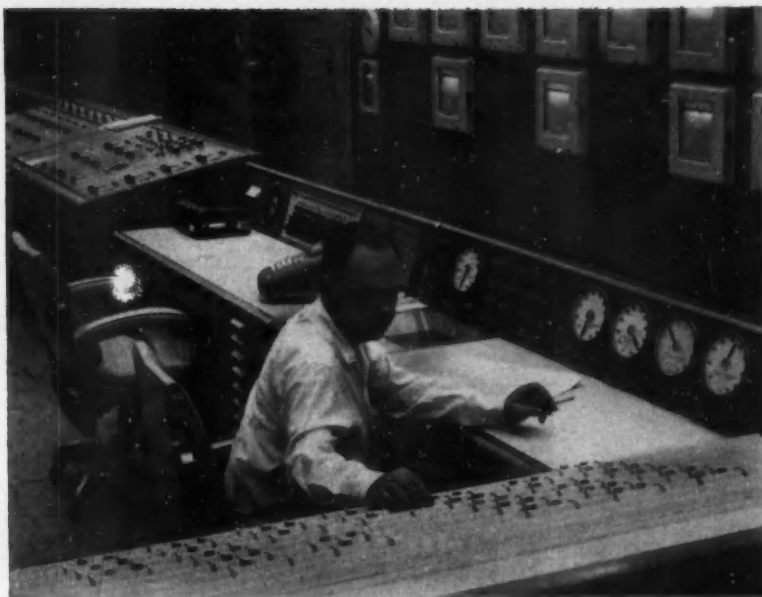
Librascope's technical ability to meet exacting requirements has ably served our many military customers in the development of missile programs. ■ For further information on Librascope's computer capabilities for missiles write:

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**CIRCLE 181 ON READER-SERVICE CARD**



## L&N computers close the control loops on 6 major power systems

### FLEXIBLE NEW COMPUTERS KEEP SYSTEM OPERATION AT OPTIMUM LEVEL OVER WIDE RANGE OF CONDITIONS

"It's gratifying to know we made the right decision." So said H. W. Page, Manager of Power Supply, Florida Power & Light Co., as he reviewed initial months of operation with his new control. He went on to say, "We know now that as a result of our decision to install this computer, we have advanced the overall level of operating efficiency on our system even more than we expected. The equipment does its job

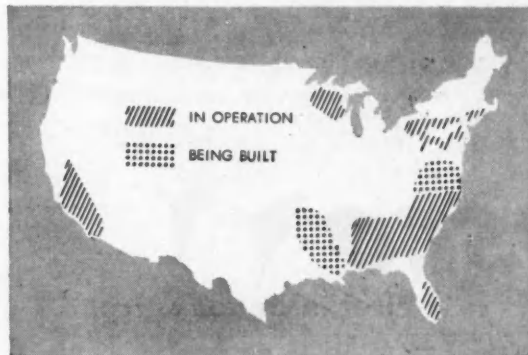
in a thoroughly dependable manner."

Suggestion: you can help *your* system make the move to advanced automatic economy dispatching more objectively—and with confidence—by checking results first . . . the actual operating results being obtained right now from California to Carolina, from Connecticut to Florida (names on request). Then contact our local office, or 4918 Stenton Ave., Phila. 44, Pa.

In operation since March, this L&N computer gives Florida Power & Light Co. the desired generation loading pattern on its nine major plants for strict incremental loading, or modified economy loading. The computer can also be used to study anticipated operating problems and their effects on the cost of operating the system while the load control is still in operation.

### GET RESULTS ON YOUR SYSTEM WITH AN L&N COMPUTER THAT:

1. Automatically loads generating units on an incremental cost-of-power-delivered basis—includes incremental generating costs and transmission loss factors (transmission loss matrix optional).
2. Provides real operating flexibility: loads on any desired incremental, or modified economy basis, to meet prevailing system conditions.
3. Plots "on-the-spot" graphic answers to problems involving economy interchange, power-flow losses or anticipated loading patterns.
4. Derives a measured lambda value—incremental cost of power delivered—at all times.
5. Invariably adjusts generation in a direction that reduces area requirement.
6. Gives each unit a terminal destination.
7. Makes it easy to place units on control—just flip a switch—no synchronization required.
8. Provides safety margins: adjustable load limit settings are positive, and cannot be exceeded; maximum rates of control action are positive, adjustable, and cannot be overridden.
9. Costs less in the long run: requires no unit or governor modifications, goes into service after approximately two to four weeks installation procedure, gives positive assurance against overregulation.
10. Is easy to operate—gives any desired readout data and, in the opinion of maintenance men, needs relatively little care.



Already, L&N computers direct the control of approximately 11,000,000 Kw over a large part of the country on systems representing a wide range of operating problems. Shaded area shows territory served by an additional 5,000,000 Kw to be put under L&N computer-control during the remainder of this year.

**LEEDS**  **NORTHROP**  
"Over 400 automatic generation control installations"

# Wide Bandwidth with True Differential Input

► Only Epsco  
Instrumentation  
Amplifiers give you  
all these features...

- WIDE BANDWIDTH... dc to 150 kc at gain of 100
- TRUE DIFFERENTIAL INPUT... true balance, low capacity
- HIGH COMMON MODE REJECTION... 200,000 to 1 dc... 50,000 to 1 ac
- HIGH GAIN... selectable gains of 100, 200, 500, 1000, 2000
- HIGH STABILITY... drift less than  $2\mu\text{v}$  per day; less than  $5\mu\text{v}$  long term cumulative drift
- LOW NOISE... less than  $3\mu\text{v rms}$  to 50 cps
- HIGH POWER OUTPUT...  $\pm 20$  volts, up to 40 ma
- 100,000 OHM INPUT IMPEDANCE
- FAST RISE TIME... 2.3  $\mu\text{sec.}$  for full scale step input at gain of 100
- WIDE DYNAMIC RANGE... unsaturating at twice nominal output
- NO ADJUSTMENTS OR CALIBRATIONS
- NO BATTERIES



With the ever-increasing need for greater accuracy in dynamic instrumentation the demand for an expanding bandwidth in signal amplification becomes more and more urgent. Epsco Instrumentation Amplifiers not only meet the bandwidth challenge, but they also provide true differential input.

Available rack-mounted or in portable units. Write for Bulletin 105801 for complete technical information and options available.

## Epsco

First in data control

Epsco, Inc., Instruments & Equipment Division, 275 Massachusetts Ave., Cambridge, Massachusetts

# Control ENGINEERING

AUGUST 1959

VOL. 6 NO. 8

Published for engineers and technical management men who are responsible for the design, application, and test of instrumentation and automatic control systems

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**Specified by Panellit —  
Supplied by CMC:**

## An Adaptable Printer with Day In - Day Out Reliability

Understandably, Panellit's requirements for a digital printer were strict. The Skokie, Illinois firm's recording annunciator, which monitors trouble in equipment operations, has to have around-the-clock reliability. It has to indicate what went wrong, exactly when it went wrong, and for how long. In many instances, the printer must operate at remote stations, unattended. Panellit chose CMC's new digital printer to provide this high degree of dependability.

### READILY ADAPTED

The tape above shows the adaptability of CMC's printer to special applications. The Panellit system scans a number of points and then records, in a single twelve digit printout, the off-normal point, the off-normal code, the hour, minute and hundredth of a minute. The date is printed every twelve hours and on demand.

The system detects the first off-normal to a one cycle accuracy and records sequentially at the rate

of four alarms per second. Alarms occurring faster are stored in the memory unit and printed according to a built-in sequence. The entire record is neat, compact and permanent.

### PRINTER FEATURES

No stepping switches ★ 4 lines per second printout  
★ parallel entry ★ 8 options... 10 line output to drive punches and electric typewriters, analog output to drive strip chart recorder, inline readout, accumulator, code converter, transistorized drive, add-subtract solenoid, print-line identification ★ rugged unitized construction ★ compatible with any line of counting equipment.

### KEY SPECIFICATIONS • Model 400C Digital Printer

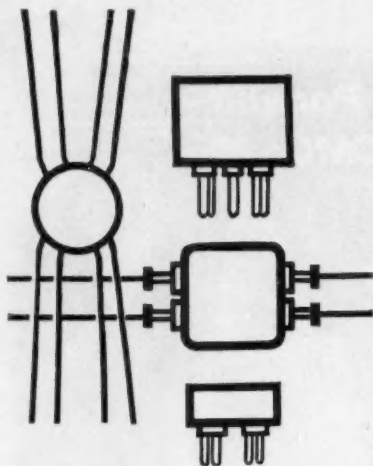
Print-out capacity 6 digits standard, up to 12 on special order. Accuracy determined by basic counting instrument... display time 0.2 seconds minimum, maximum controlled by counter or system. Weight 64 lbs.

CMC engineering representatives are located in principal cities. For complete information on this all-new instrument, phone your nearby representative or write directly to Dept. 088.



**Computer-Measurements  
Company** A Division of Pacific Industries, Inc.

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Sylmar, California



**Sprague offers  
standard and special**

## **PULSE TRANSFORMERS**

**for military and  
commercial applications**

Standard or special... military or commercial... in any size or shape... Sprague Pulse Transformers are designed to give top performance... in high-speed computer circuits, pulse inversion circuits, impedance matching circuits, blocking oscillator circuits, and many others.

Special designs for high acceleration, high ambient temperatures or minified circuits can be furnished to suit requirements. Units are also available in lower-cost commercial housings.

For engineering assistance on your pulse transformer problems, write to Special Products Division, Sprague Electric Company, Union St., North Adams, Mass.

# **SPRAGUE®**

**THE MARK OF RELIABILITY**

**CIRCLE 6 ON READER-SERVICE CARD**

**CONTROL ENGINEERING**

## **SHOPTALK**

### **Testing—one, two, three**

Test is the step that tells you whether you've succeeded, or whether you're even heading in the right direction. In research, tests will tell you if a new family of missile fins has the proper stability characteristics; in design, tests will tell you if a new gage control system meets specifications; and in improvement studies, tests will tell you how to modify a control system to increase process throughput. As technology becomes more complex and test requirements more exacting, control engineers are called in to measure the test variables, transmit the data, and record and process the test results, regardless of whether the test is to measure the bending moment in a ship model or to study the flight characteristics of a new adaptive autopilot.

All of this is to explain why we chose test as the theme of our September 1959 Fifth-Anniversary issue. Following on the heels of "How to Practice Control Systems Engineering" (Sept. '56), "Computing Control" (Sept. '57), and "Program Control" (Sept. '58), next month's issue will cover how to plan efficient tests; what to test and when (the actual process or equipment, scale models, analogs, breadboards); how to measure, transmit, record, and process test data; and many case studies emphasizing pertinent points of the test routine.

As an added attraction, Editor Bill Vannah will take over September's Industry's Pulse for a review of the highlights of the last five years of control engineering. Don't miss the next issue.

### **A reminder; we'd like to hear from you**

Be sure to let us know what you think of CtE placing advertisements between all feature articles so that each article can be torn out and filed separately. The July issue was laid out that way and so's this one. We're sitting back now waiting for the screams or cheers.

### **The little man who wasn't there**

When Managing Editor By Ledgerwood asked Joe Albert and his boys from Georgia Div., Lockheed Aircraft for assistance in preparing the maintenance article (page 73) they were quick to respond, but the response was in rather unusual form. Instead of a letter, By got back a magnetic tape. Being busy, they'd all sat down around a table and run off a half-hour tape on maintaining numerical control systems. The interesting thing was that they created the impression that By was right there at the conference; for instance, each man introduced himself, addressed his comments to By, and said goodbye at the end. A refreshing way to gether material for an article.

10,000 megohms? 200 volt swings?  
with transistors?

**YES** Adage does it!



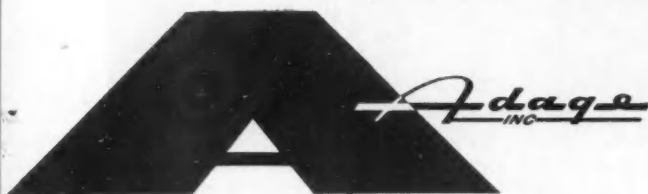
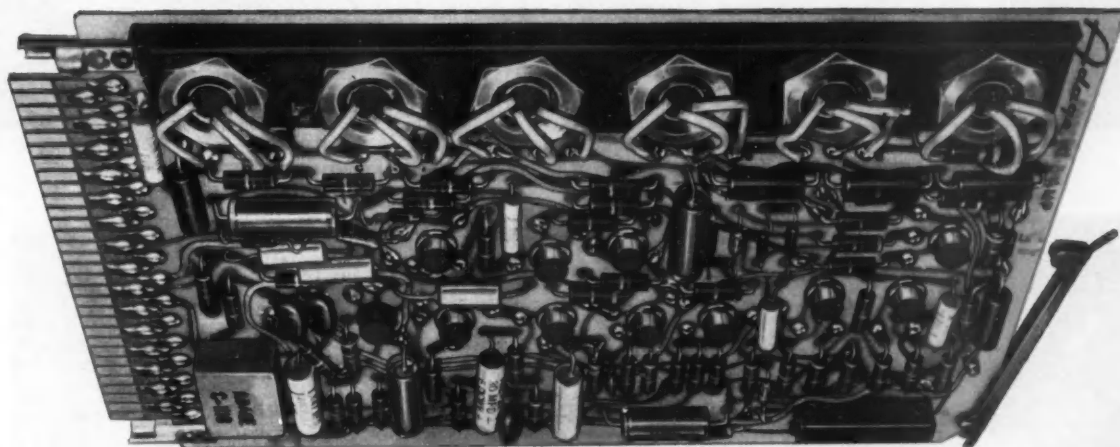
Yes, it can be done! Adage Engineers have laid two widespread myths to rest! Transistors can provide high output voltage swings. Transistors can provide very high input impedances.

Newest of the Adage all-transistor circuit modules, the CV-HZA High Impedance Amplifier, handles high voltages and at the same time provides an extremely high input impedance. Used as an isolation amplifier it permits precise voltage measurements without disturbing the signal source. Errors due to circuit loading are eliminated. Full scale signal swing is greater than  $\pm 100$  volts. Input impedance is many thousands of megohms. All this, and rise times on the order of a few microseconds, too.

The CV-HZA functions as a direct-coupled voltage follower. Voltage gain is precisely unity. A unique semi-conductor chopper stabilizing technique results in excellent long term d.c. voltage stability. Long term reliability has been proven by extensive field testing.

This revolutionary device can be ordered as an integral pre-amplifier in Adage Voldicon voltage-to-digital conversion equipment, or it may be ordered separately. It will solve many circuit loading problems for users of Analog Computers, Automatic Test Systems, Potentiometer Measurement Equipment, etc.

Two models are presently available:  $\pm 100$  volts (model CV-HZA);  $\pm 10$  volts (CV-HZA10)

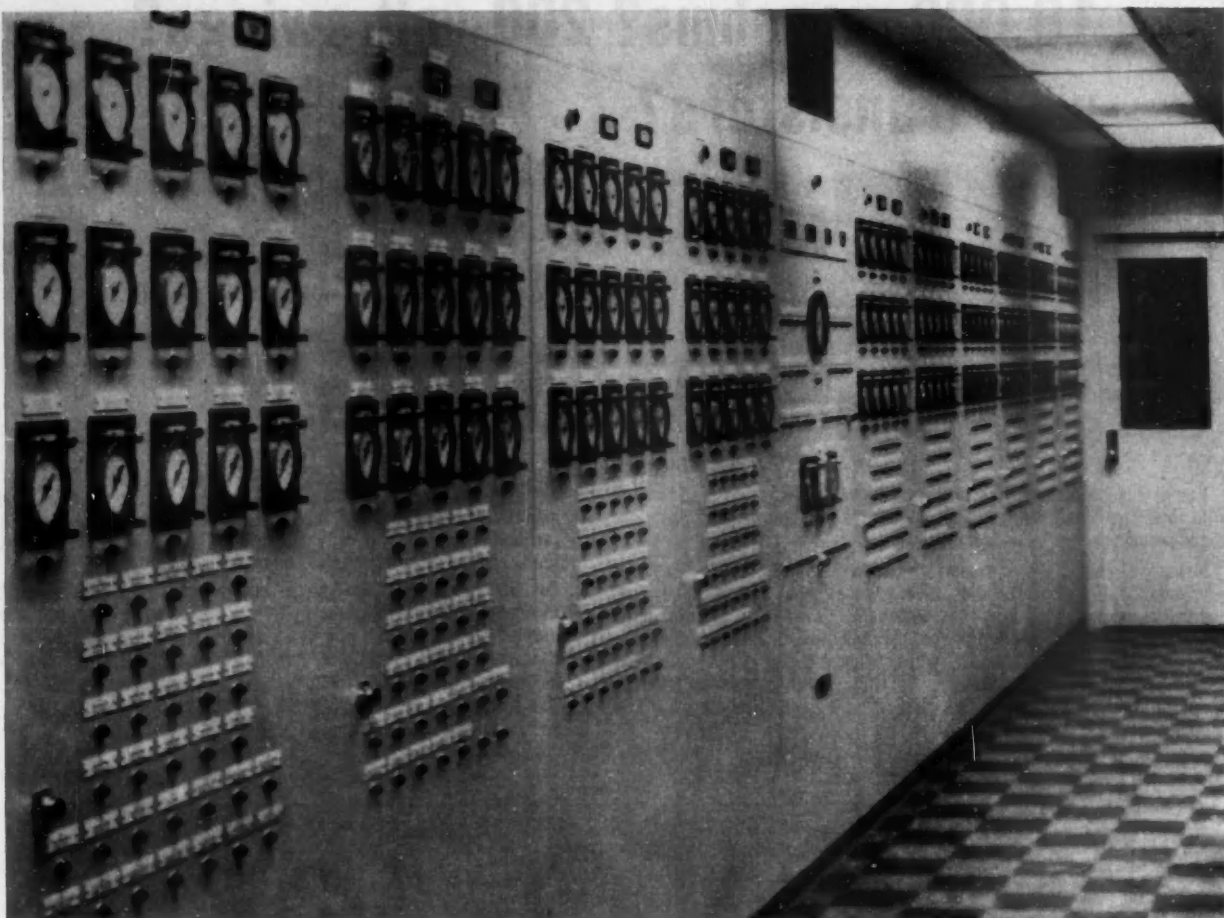


292 MAIN ST., CAMBRIDGE, MASS., Dept. CE-8

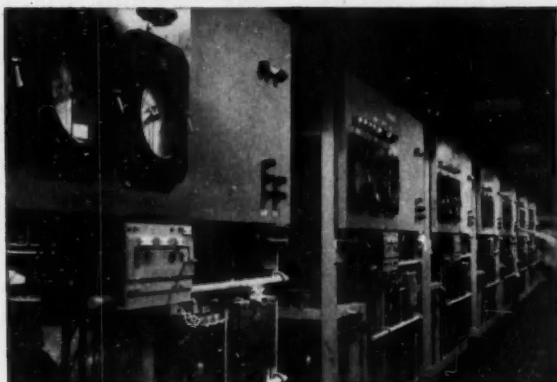
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write  
today for  
complete  
technical  
specifications

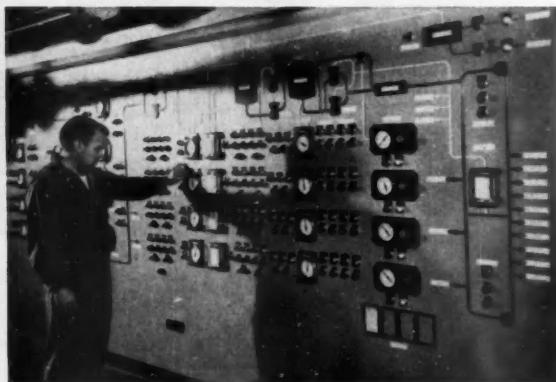
CIRCLE 7 ON READER-SERVICE CARD



Central control room which provides indicated and printed evaluation of casting machine operations by means of Taylor TRANS-SCAN-LOG system. Typewriters under plastic covers behind operator.



Taylor FULSCOPE® Controllers maintain correct temperature in the wet churns. They receive signals from TRANSAIRE® Transmitters equipped with flat bulbs installed flush with the inside of the churn walls.



One man oversees the viscose filtration and deaeration process from this master Graphic Panel. Taylor miniature indicating and recording instruments enable the operator to quickly pinpoint any abnormal conditions.

# Taylor Instruments



## Men, machines and Taylor

### Instruments join forces to produce

### superior **AVISCO** cellophane

American Viscose Corporation selected Taylor to furnish the bulk of the instrumentation for the new cellophane plant at Marcus Hook for two main reasons—Taylor's close association with the cellulose industry, and confidence on the part of American Viscose in Taylor Instrument Companies and its products developed over many years.

Designed for a capacity of 50,000,000 lbs. of cellophane per year, this plant is among the most modern of its type in the world. Wherever practicable, continuous processing has taken the place of batch operations, necessitating extensive use of automatic control of important process variables at almost every stage.

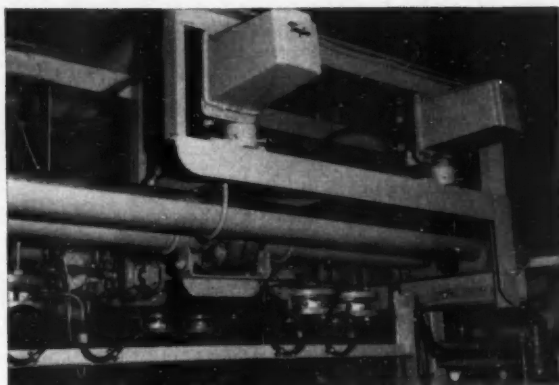
Photograph at left shows the control center for the important casting area—the largest and most precise control system of its type in any industrial plant, outside of the atomic energy field. Here the Taylor TRANS-SCAN-LOG\* system enables one operator to

monitor and supervise the overall operation of this stage of the process. Signal lights show at a glance abnormal conditions anywhere in the process. At hourly intervals—or on demand—a typewritten record of all variables is automatically prepared (typewriters shown behind operator). In addition, the operator may select a specific variable, or group of variables, for reading at any time. This system permits operation within closer tolerances than could possibly be obtained with conventional instrumentation.

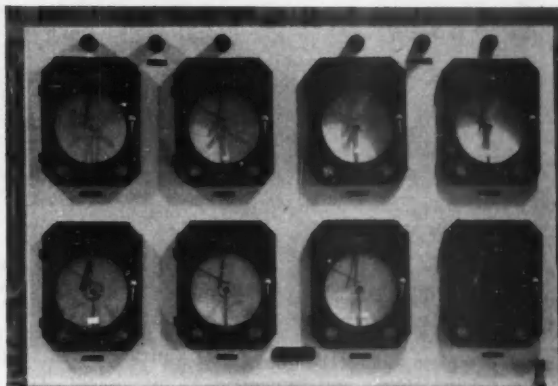
The result, American Viscose tells us, is better, more continuous production and higher quality product.

A Taylor control system may be the answer to your product quality problems—and cut your operating costs too. Why not call in your Taylor Field Engineer, or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Ontario.

\*Reg. U.S. Pat. Off.



Acid flow measurement is accomplished with Taylor 205T Volumetric DP Transmitters, connected to the process by filled capillary systems and diaphragm seals of Hastelloy. Signal is transmitted to the data logging system.



Master control panel for one of the coating towers. Instruments regulate supply of lacquer to the coater, flow and pressure of air for drying, and temperature and humidity conditions within the tower.

VISION • INGENUITY • DEPENDABILITY

## **MEAN ACCURACY FIRST**

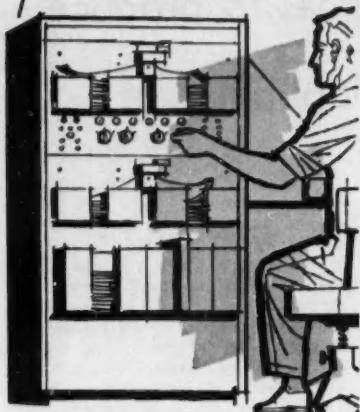
CIRCLE 9 ON READER-SERVICE CARD

AUGUST 1959

9

This is the New

# TALLY



## Tape Preparation & Editing Console

### *It makes error-free paper tape*

By automatically verifying and/or duplicating paper tapes. The console consists of a numerical keyboard, two punch tape readers and one tape perforator. The buffer storage system uses unique Tally Logic Switches.

### *It features...*

- Tape to tape duplication and verification at 60 characters per second
- Keyboard visual display and shift register to eliminate copying errors and operator fatigue in both punching and verifying modes
- Tape corrections without over punching or splicing.

### *It's ready for delivery now*

For complete technical information, prices, delivery, and the name of your nearest Tally engineering representative who will be happy to arrange for a demonstration, please address Dept. 088.

→ **TALLY**  
REGISTER CORPORATION  
5300 14th Avenue N.W., Seattle 7, Wash.

See this Console and other tape handling equipment at WESCON, Booth 119.

CIRCLE 10 ON READER-SERVICE CARD

10 CONTROL ENGINEERING

## FEEDBACK

### READERS' CONTROL WORKSHOP

#### Question on Slitting and Sheeting

TO THE EDITOR—

Many of your articles have been read with interest by members of our firm. As recent subscribers to your publication, we are writing this letter in the hope that you can assist us in finding a solution to a control problem we have.

We manufacture plastic products for the stationery trade. Our operation is essentially one of converting raw material to finished goods. The raw material consists of cellulose acetate, vinyl, leatherette, and paper. It comes in rolls from 40 in. to 54 in. wide and from .002 in. to .040 in. thick.

At the present time we have this material processed elsewhere on a sub-contract basis. Processing consists of slitting the rolls to smaller widths, and/or sheeting the rolls to rectangular sheets. We contemplate setting up a production line whereby it shall be possible to unwind a roll of material having a maximum width of 60 in. and to cut it into rectangular sheets having an infinite variety of lengths from  $\frac{1}{4}$  in. to 60 in. This line shall incorporate a roll unwind mechanism, feed rollers, a production cutter, and a conveyor table.

We desire some sort of control mechanism whereby we can precisely control the length of a cut. This control mechanism should enable us to control the length of the first cut of a roll as well as the lengths of suc-

ceeding cuts. The tolerance involved would be plus or minus  $\frac{1}{16}$  in. The control mechanism should be automatic and be able to detect and make any necessary corrections so as to provide for the correct length. We have not determined whether this device should be controlled by mechanical, electrical, fluid, or optical means.

Sanford Beim  
Kingsbacher-Murphy Co.  
Los Angeles, Calif.

#### A Thoughtful Answer

TO THE EDITOR—

In recent years, greater progress has been made in thickness and width control of sheet products than in sheet-length control. The metals industries, for instance, have been looking for very accurate measurement (in control, measurement is the first step) of length of steel strip. We know of no reasonably-priced systems for measuring the length of continuous strips to the accuracy required in the question statement. One could be designed, but we doubt that it would be economically rewarding unless the annual throughput were of the order of \$5 million. Therefore, in our opinion, the starting point for such an application should be an economic study of present processing costs.

H. R. Chope  
Industrial Nucleonics Corp.  
Columbus, Ohio

#### Information, please—quality control

TO THE EDITOR—

We have been assigned a project to plan a "system for the quality and production control" of electronic tubes and transistors.

As in Italy there is no particular literature on the subject of quality control, we beg you kindly to indicate to us the titles of some publications which will introduce us deeply to the matter and at the same time can explain to us from which basic elements we can start in order to confront such a plan.

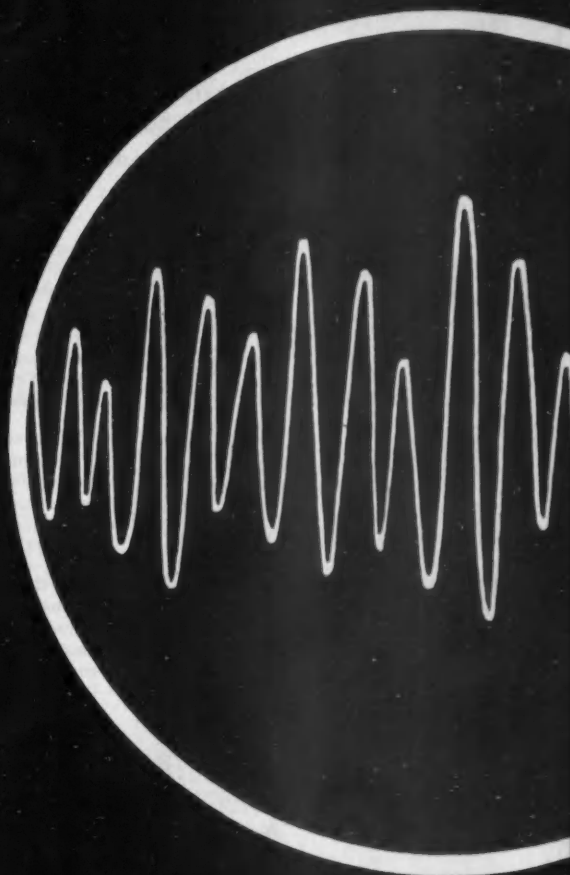
We should be very pleased to have

a friendly contact with some of your engineers for some eventual explanations, should we find difficulties during our study.

Enrico Valenti and Enrico Gnaro  
University of Genoa  
Genoa, Italy

We enclose tearsheets from the April, '59 issue of Control Engineering describing a transistor tester developed by Texas Instruments, Inc.

For much broader information, we strongly suggest that you obtain a copy of the transactions of the meeting of the American Society for Quality Control, held in Cleveland on May 25, 26, and 27 of this year. These can



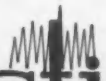
## WHAT YOU SHOULD KNOW ABOUT ULTRASONIC EQUIPMENT

The "miracle" of ultrasonic energy is based on definite scientific and engineering principles that govern its application to your needs. The efficiency of your ultrasonic equipment depends on its **Quality**. Whether you use ultrasonic equipment for more thorough cleaning of electronic components and intricate instruments—or whether you control the level of fuel by the highly accurate ultrasonic method—the vital factor is **Quality**. The result you get from the equipment you use is no better than its **Quality**.

Acoustica is the world's foremost producer of quality ultrasonic equipment. Acoustica research and

Acoustica facilities are unequalled. Make the most of the great advantages that the ultrasonic method offers by always specifying **Acoustical**! Write for information concerning your ultrasonic needs in cleaners and liquid level switches. Acoustica Associates, Inc., Fairchild Court, Plainview, N.Y. • 10402 Aviation Blvd., Los Angeles, Calif.

See us at our Wescon booth

  
**acoustica**  
THE GREATEST NAME IN ULTRASONICS

CIRCLE 11 ON READER-SERVICE CARD

# NERVE CELL ANALOGY

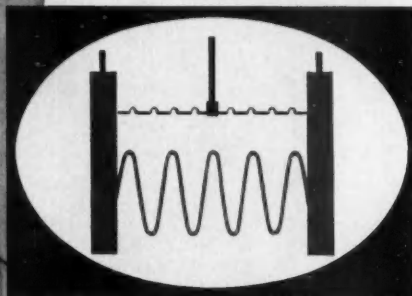
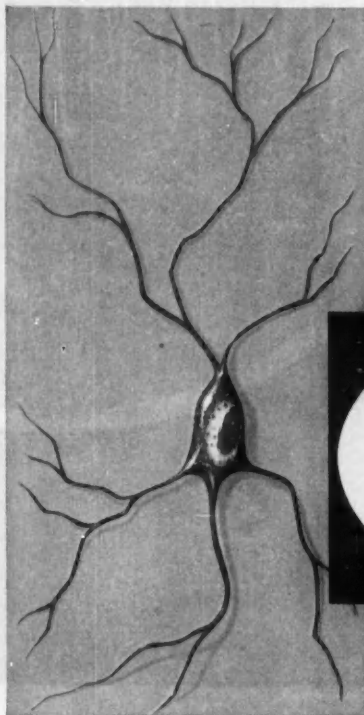
## CONTROL THROUGH ELECTRO-IONIC SURFACE IMPEDANCE CHANGES

An important new and basic contribution to the art of switching and modulating high wattage AC circuits

According to all modern theory of the metabolism and function of the neuron, or individual nerve cell, this highly efficient and ultra reliable control component is surrounded by a semi-permeable membrane which is charged positively on the outside and negatively on the inside.

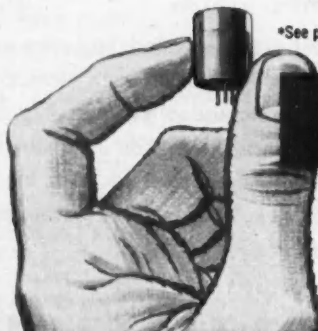
When a stimulus reaches the surface of this membrane, its permeability to certain ions increases with a corresponding decrease in resistance—and its surface becomes activated by a spreading wave of potential.

This change in permeability during the passage of an impulse is accompanied by impedance changes on the membrane—thus effectively controlling the "output" of the large energy potential.



**Control Engineering**—in its July issue, carried the first editorial disclosure\* of a significant new advancement in static control in which the basic phenomena of surface impedance changes are applied to achieve ultra reliability in switching and modulating high wattage AC circuits by very small signal means. A further report on the commercial development of such devices will appear in the September issue.

\*See pages 121-124. Reprints available upon request from:



**Ovitron**  
CORPORATION

14830 Schaefer Highway  
Detroit 27, Michigan

CIRCLE 12 ON READER-SERVICE CARD

CONTROL ENGINEERING

## FEEDBACK

be obtained by writing to Wade R. Weaver, Registrar, Republic Steel Corp., Cleveland 1, Ohio. The papers cover a broad range of quality control subjects and will probably give you some food for thought in addition to the names of people to contact in this country. Ed.

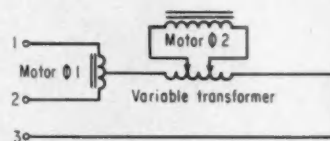
### Missing, one sliding contact

TO THE EDITOR—

The edited version of our "Transistor-Thyratron" article, pp. 118-122, in the April issue was nicely done. However, there is an error in the Scott-connected three-phase auto-transformer schematic. Looking back at my records, I find the same error in our first draft. I thought it was corrected in our last draft. Below is the correct circuit.

Note that as the sliding contact of the variable transformer moves from the center tap outward in one direction, the motor increases torque in that direction. If turned from the center tap in the opposite direction the motor reverses.

E. W. Taylor  
Diehl Mfg. Co.  
Somerville, N. J.



### Wants references on 'copter control

TO THE EDITOR—

"Bringing the Helicopter Under Control", an article published in the January '59 issue of CONTROL ENGINEERING, pp. 71-76, lists references. How may I obtain them?

Martin C. Stettler  
1549 35th St., N.W.  
Washington 7, D. C.

The references Mr. Stettler requests are listed below. After each one is the name and address of its source. Ed.

1. HELICOPTER THEORY, T. H. von Karman, "Zeitschrift für Flugtechnik und Motorluftschiffahrt", Vol. 12, 1921. Translated in "Aircraft Engineering", Sept. 1940.

"Aircraft Engineering", Bunhill Publications, Ltd., 12 Bloomsbury Square, London WC 1, England.

2. HELICOPTER ANALYSIS, A.

# FIELD PROVEN...

## Honeywell Electro Hydraulic Tracer Systems

Now operating on a wide variety of well-known machine tools (some of them illustrated at the right), Honeywell 180° and 360° Tracer Control systems provide fast, accurate and reliable system response for smooth application of large increments of hydraulic power.

They combine the flexibility, remote control and finesse of electronics with the power and fast actuation of hydraulics. They're far more flexible than completely hydraulic systems. These systems have been designed for ease of application. Modular construction simplifies and speeds field service.

**Accuracy**—Accuracies of  $\pm .0005"$  from template to part and  $\pm .0002$  from part to part have been achieved in actual use.

**Adaptability**—These systems are now in operation on all types of machine tools, from light duty engine lathes to huge spin forging machines. Every application is custom fitted—at production line prices.

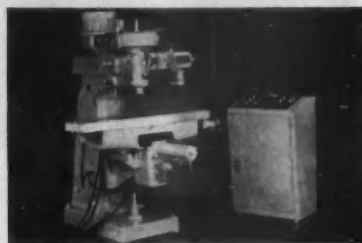
**Performance**—Each Honeywell system becomes an integral part of the machine tool. The control system can be adjusted to compensate for changes in machine performance during the life of the machine. Speed range of 300 to 1 is normal; greater rangeability is available on some applications. Tracing speed ranges up to 60" per minute are available.

For further information on Honeywell's new machine control systems and components and their application to your specific job, contact Minneapolis-Honeywell, Machine Control Group, Dept. CE-8-93, Minneapolis 8, Minnesota.

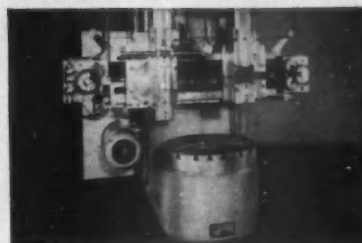
## Honeywell



*First in Control*



Gorton Vertical Milling Machine equipped with Honeywell 360° Electro Hydraulic Tracer Control System.



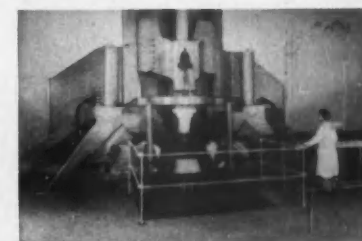
Giddings & Lewis vertical turret lathe with Honeywell 360° Electro Hydraulic Tracer Control System.



Frauenthal Division of Kaydon Engineering Corporation turning and grinding machine with Honeywell 180° Electro Hydraulic Tracer Control System.



Rockford Machine Tool Company hydraulic mill with Honeywell 180° Electro Hydraulic Tracer Control System. Swarfing operation.



Hufford Corporation spin forge machine with two Honeywell 360° Tracer Control Systems plus spindle speed control.

# MEN

Basically, the rapid advances made by Bryant in the field of magnetic storage drums are due to the technical capability and long experience of Bryant's research, engineering and production men. Full details are in our new descriptive brochure.

Write for your copy. Bryant Computer Products Division, a division of Bryant Chucking Grinder Company, P. O. Box 620, Springfield, Vermont.

CIRCLE 14 ON READER-SERVICE CARD  
CONTROL ENGINEERING

## FEEDBACK

A. Nikolsky, Wiley, 1951.

John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y.

3. AERODYNAMIC STABILITY AND AUTOMATIC CONTROL, William Bolley, "Journal of the Aeronautical Sciences", Vol. 18, Sept. 1951.

"Journal of Aeronautical Sciences", c/o Institute of Aeronautical Sciences, 2 East 64th Street, New York 21, N. Y.

New party game for engineers?

TO THE EDITOR—

I have been reading your Reprint Order Form for a number of months to see if you would catch up with the title, "How to Stimulate Dead Time". It sounds like an excellent title for a party book, but I'm not too certain where it fits in control work.

J. E. Beach  
Jackson, Mich.

It's a pretty good idea at that. Error caught, the reprint title now reads "How to Simulate Dead Time", hardly so stimulating. Ed.

Left out, wants in

TO ABRAHAM M. FUCHS—

We noted with great interest your series of articles on control system test equipment in CONTROL ENGINEERING. We were very disappointed, however, to see no mention made of our Model SV-1 Servo Analyzer.

We think that our Model SV-1 is a great deal more versatile than the equipments described in your series.

A. H. Sonnenschein  
Polarad Electronics Corp.  
Long Island City, N. Y.

Get a catalog sheet from Polarad and judge for yourselves, readers. Ed.

Information, please—ore-bin control

TO THE EDITOR—

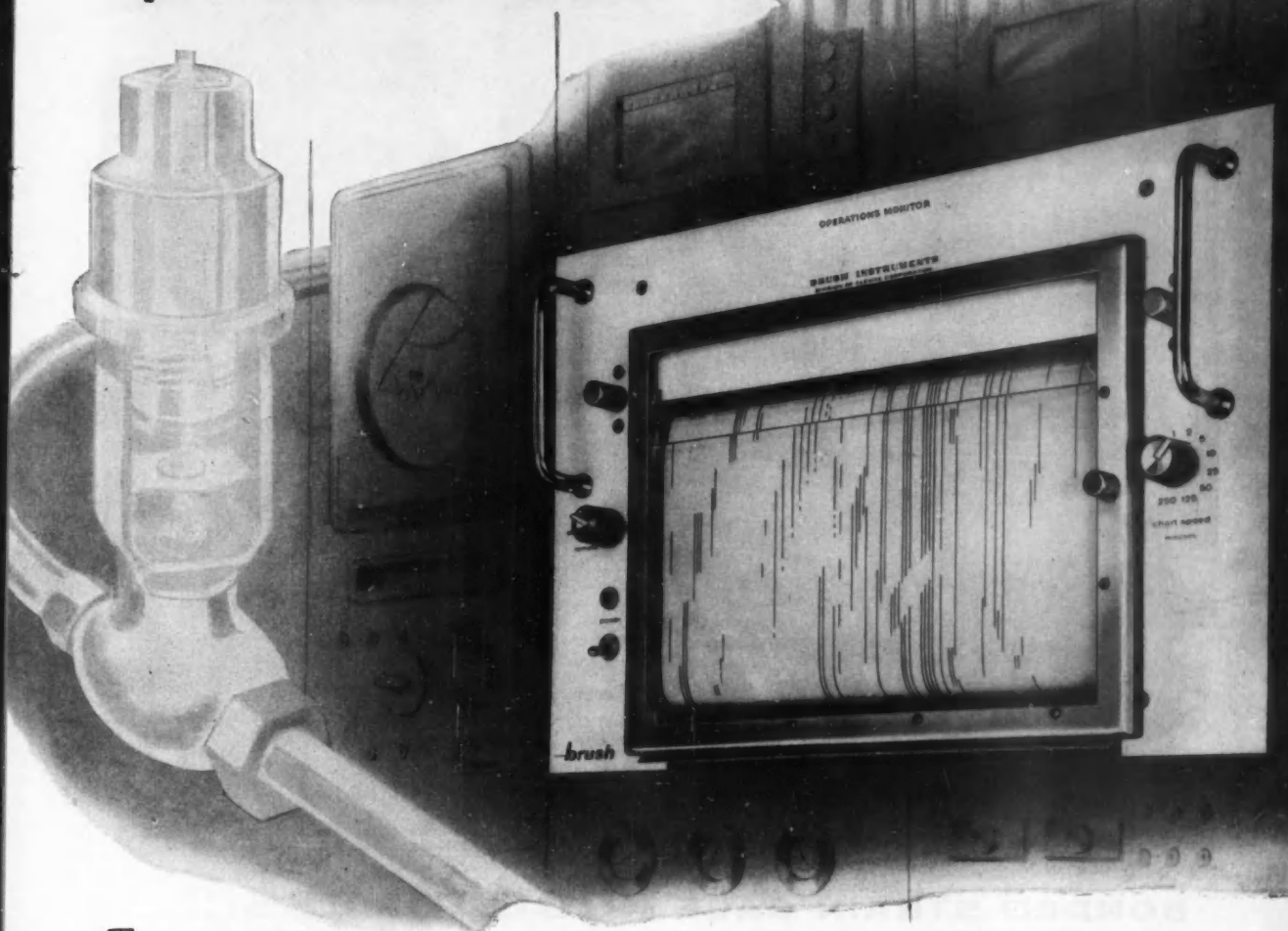
Would it be possible to send us further information on the system described on page 128 of the April issue of CONTROL ENGINEERING. This article was titled "Transistors Prevent Channeling in Ore Bins".

Fred Fixari  
Chain Belt Co.  
Milwaukee, Wis.

Contact C. M. Marquardt, Industrial Physics & Electronics Co., 470 South Tenth St., Salt Lake City 2, Utah. Ed.

CIRCLE 15 ON READER-SERVICE CARD →

# 100 processes recorded on One Brush Operations Monitor!



**T**his compact Brush Operations Monitor can improve the control of power distribution systems, chemical processes and automated production lines.

On a moving chart only 12" wide, 100 separate operations can be recorded at the same time . . . what happens or doesn't happen . . . monitoring present recording and indicating devices. For example, the opening or closing of a valve . . . the

action of a relay . . . the control of motors . . . all are documented in a time relationship to other operations. You get an immediate picture of an *entire situation* at any time. Sixteen different time bases can be selected from remote or on-the-spot locations.

**WRITE FOR FREE BOOKLET...** "Brush Operations Monitors for Supervisory Analysis and Control." Contains specifications and application data.

**—brush INSTRUMENTS**  
DIVISION OF  
37TH AND PERKINS **CLEVITE** CLEVELAND 14, OHIO  
CORPORATION



NORWOOD  
CONTROLS

## PRESSURE TRANSDUCERS



### BONDED STRAIN GAGE RUGGEDNESS

No damage at 1,000 g to 2,000 cps . . . no unsupported fine wires to resonate or fracture.

**2 In 1** — BOTH static AND dynamic measurements with ONE transducer . . . for use with any read-out equipment from standard strip-chart recorders to cathode ray oscilloscopes.

**PLUS** — 4 arm 350 ohm strain gage bridge . . . high dynamic response: natural frequency 50 KC; damping constant .2 (cooled) . . . only  $\frac{1}{4}$  of 1% maximum zero shift when flame of acetylene torch passes rapidly over diaphragm . . . all welded diaphragm for corrosive applications . . . ranges: 0-25 to 0-60,000 psi.

**WRITE** for data sheets covering  
Norwood Controls Transducers,  
Norwood Controls Unit, Detroit Controls  
Division, 938 Washington Street,  
Norwood, Massachusetts.



**AMERICAN-Standard**

DETROIT CONTROLS DIVISION

# Nathan Cohn

## grew up with utility control

When Nat Cohn graduated from MIT in 1927 (with an S.B. degree majoring in electrochemical engineering), the electric utility industry was just beginning to use automatic generation controls to supplement conventional speed governors. Practically the only automatic control was for the simple regulation of frequency. Control was restricted to a utility's own system, often to a single generator.

During his 32 years with instrument maker Leeds & Northrup Co., Nat has watched this interest mushroom until today U.S. utilities are tied together in complex power pools—all automatically controlled; they automatically load their systems with electronic dispatch computers. Nat Cohn has not only watched this advancement in control technology, but he has contributed heavily to it.

Nat was first attracted to the field of instrumentation in his last year at MIT. While preparing his senior thesis, "Characteristics of Colloidal Condensers", he was intrigued more by the measurement aspects than by the electrochemical portions. He took up with MIT Prof. Frank "Pop" Laws (one-time U. S. dean of measurement) a job offer from Leeds & Northrup. Pop Laws was leery of the opportunity. "That company's getting too interested in industrial applications," he warned his student. But the ability to put numbers on things proved too much of a temptation; Nat moved to Philadelphia as soon as he graduated, to take L&N's training course.

After six months, he went on the college circuit, selling laboratory instruments, recorders, and controllers. To the enthusiastic young man, it was a wonderful job. It gave him a chance to talk to research people about what was new and what was needed, and occasionally it brought him into a power plant—with an occasional recorder or controller sale.

He moved to San Francisco in 1930 as L&N's district manager (and as the entire sales and service force there). Steam generation was just starting to become an important factor in the west. Most activity was on hydro-electric projects. Utilities were only beginning to explore generation controls.

While in the west, Cohn worked on some of the most interesting pioneer applications. For example, with the chief user (City of Los Angeles) engineers, he laid out the instrumentation for Boulder (now Hoover) Dam—one of the biggest instrumentation jobs of the depression-riddled thirties. Later he helped plan one of the earliest industrial telemetering installations in the west.

After this, unique power plant jobs seemed to gravitate to Nat Cohn. For the city of Vernon (Calif.) he made one of the first applications of frequency, time, and load distribution control for a diesel station, controlling five diesel units. For the city of Seattle, he helped plan similar controls for the Diablo Dam project. And he laid out the instruments and controls for the first unit of the big Bonneville Dam project.

About the time he moved to Chicago in 1936 to become L&N's midwest district manager and technical

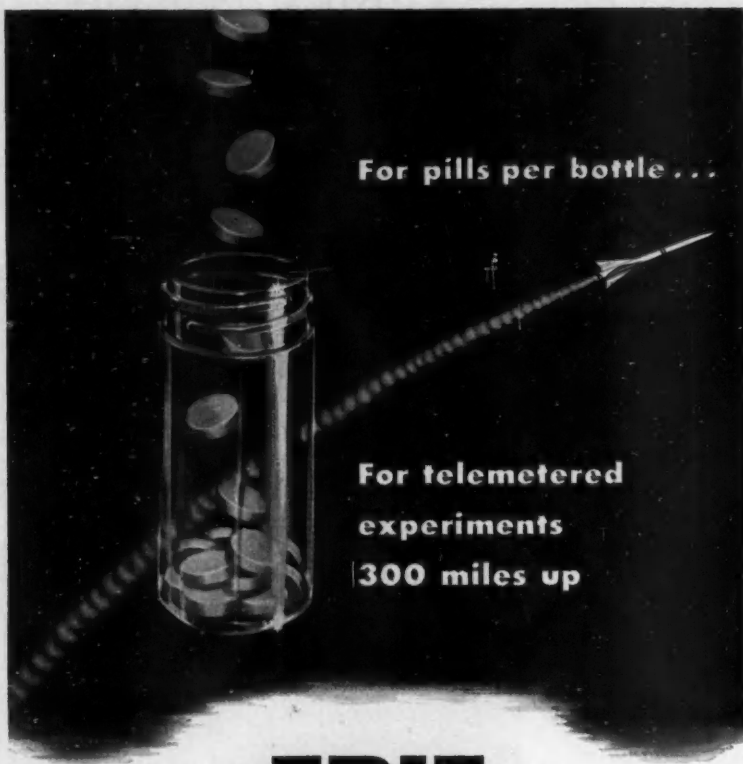


director, something new was happening to the utility industry. Utilities were starting to interconnect their lines and were discovering a brand new control problem: how to regulate these new tie lines so that each utility would take its share of total generation. Tie lines are set to handle a scheduled flow of power. The control problem is complicated by unexpected disturbances that disrupt or change the scheduled flow.

Helping solve such problems started Nat off in a new direction. Working closely with utility engineers, the highly articulate engineer did a lot of application engineering on table cloths in restaurants to explain and sell the string of ideas he originated.

But his greatest contributions were to come in tie-line bias control. In this arrangement, all areas but one were on tie-line bias; the single area controlled frequency, taking up any "slop" in regulation. The big problem was how much each area should be biased—meaning to what extent stations should pick up generation if trouble appeared elsewhere on the interconnection. Many utilities urged a small bias, fearing they would otherwise upset their own areas or would carry more than their share of the load.

In a brilliant interpretation of tie-line bias control, presented at a special meeting in 1956 of utility pool groups, Cohn analyzed the effect of different bias settings, and derived equations for the magnitude of response. This gave the utility men a basis for agreeing on preferred settings, thus resolving a controversy that had smoldered for many years. The presentation was so outstanding that he was asked to prepare an AIEE.



## ERIE COUNTERS and TIMERS

Some users want a slow count for mechanical or process control... "50... 125... 250" aspirins.

And some want a fast count... "98,999... 99,000... 99,001" in a second.

And you may even want to telemeter frequency and time interval and sequence all in a few instants.

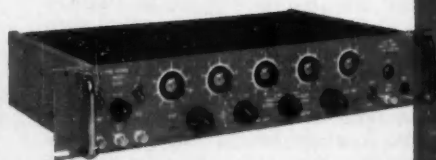
ERIE-Pacific Digital Instruments can:

- count events • measure frequency, period, time intervals
- function as preset and control devices • determine sequence

Seven catalog models of ERIE-Pacific instruments are available: the Model 210 Digital Timer, the Model 130 Frequency Counter, Model 100T Digital Tachometer-Counter Transistorized, Model 320 Preset Counter, Model 660 Low Frequency Monitor, Model 700 Digital Scanning Counter, and the Model 400 100kc Universal Counter-Timer illustrated below.

Literature on the ERIE-Pacific line of instruments is available on request along with the name of your local ERIE-Pacific sales engineer. Write to:

*One of the Erie line...*



Model 400 Universal Counter-Timer with frequency 1 cps. to 100,000 cps., time interval 0.5 MS to 278 hours, and only 19" x 3 1/2" x 10". Weight: 15 lbs. \$695.00.



Openings now for engineers qualified in electronic digital instruments and systems.

CIRCLE 18 ON READER-SERVICE CARD

CONTROL ENGINEERING

NAT COHN . . .

paper incorporating it; it won an AIEE prize that year.

Although bias tie-line control solved one part of the power pool problem, how to allocate generation demand to the cooperating utilities, another part of the problem remained: how to achieve the required area generation most economically. By 1950, utilities were following an approach in which they set one station up as a master and related other stations to it. Cohn felt it would be better to relate station programming to total generation rather than one station which might be fast or slow and therefore would make all other stations fast or slow.

To solve this, Nat proposed programming reference combining feedback and feed forward. He was awarded a patent on a system which adds the prevailing total generation (a feedback) to the power required to meet the area demand (a feed forward) to compute the total desired output of the area. His equation:

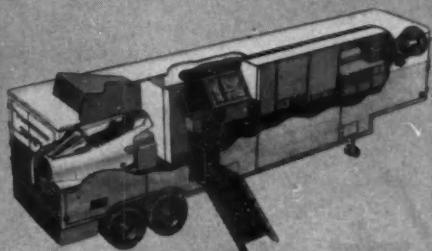
$$AR = \sum SR$$

(where AR is the area requirement, the amount necessary to bring the area generation up to a total demand, and SR is the amount required from each generating station) makes the system independent of the response rates of each source. A paper describing this system won an AIEE prize, and was responsible for Cohn's being made a fellow of AIEE in 1954.

For it, he won other honors, too. Nat Cohn suddenly found himself elected to Eta Kappa Nu, honorary electrical engineers fraternity, Tau Beta Pi, honorary engineering fraternity and Sigma Xi, honorary research and science fraternity.

In 1955, Nat was transferred to Philadelphia where he was made manager of market development. In 1958, he was elected vice president, technical affairs—in charge of R&D, engineering and the Patent Div. This brings Nat full circle in his career at L&N. After 32 years, he's back talking to research people about what's new and what's needed in instrumentation and controls.

His new job is to keep L&N up to date in precision measuring and in pertinent aspects of control, including such glamorous items as a computer for process control, new sophisticated on-stream analyzers, and advanced controllers and recorders. But Nat also feels that there's "glamor in profit" and he also presses for the development of bread and butter products to be sold in large quantities.



#### NEW LINK F8U-1 JET FIGHTER TRAINER

The mobile F8U-1 is one of the latest flight simulators built by Link Aviation, Inc., subsidiary of General Precision Equipment Corp. The F8U-1 includes cockpit, instructor's area, computer sec-

tion and maintenance shop in an air-conditioned trailer. In World War II, famous Link "Blue Boxes" trained over half-million Allied airmen. Today, Link units like the F8U-1 ready commercial and military pilots to handle jet aircraft.



## Tung-Sol tubes help **LINK** AVIATION, INC. trainers put fledgling pilots in the air!

A Link electronic trainer acquaints both the beginner and experienced pilot with precise flight conditions from takeoff to touchdown. It familiarizes him with on-ground responsibilities . . . teaches crew coordination, radio procedure, navigation, instrument flying . . . and records student reactions. The fledgling gets the 'feel' of flying without ever leaving the ground.

The complex and sensitive simulators function over long periods and get rough treatment from beginner hands. Precision operation demands more-than-ordinary reliability and performance from every simulator compo-

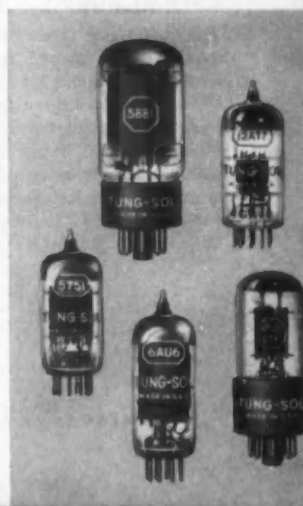
nent, including up to 3,000 electron tubes.

Tung-Sol dc summing amplifier tubes and buffer tubes used in the various Link simulators consistently meet these exacting requirements. The tubes feature outstanding electrical stability . . . ruggedness under hardest usage . . . minimum short-life failure rate. And tube quality stays uniformly high from one tube lot to another.

The same premium tube performance Link enjoys is available to you. Specify Tung-Sol power tubes for any military and industrial socket you must fill! Tung-Sol Electric Inc., Newark 4, New Jersey.

**ts TUNG-SOL®**

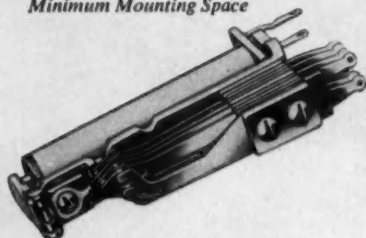
CIRCLE 19 ON READER-SERVICE CARD



# Choose the right relay

## FOR YOUR APPLICATION

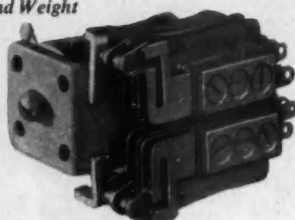
*Minimum Mounting Space*



### **CLASS C RELAY:**

Incorporates many design characteristics found in the Class B relay, but is only half its width. Use wherever quality is mandatory, but space is at a premium. Quick- and slow-acting types available for operation at up to 150 volts d.c. Supplied with two to twelve contact springs.

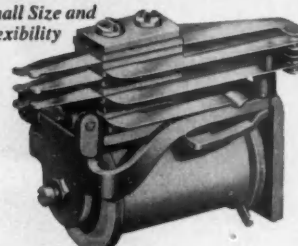
*Minimum Size and Weight*



### **CLASS S RELAY:**

This miniaturized relay saves space and reduces weight to a minimum in aircraft and similar applications. It provides high contact pressures and absolute contact reliability under extreme conditions of vibration, shock and humidity. The relay is characterized by its small mass and low self-inductance.

*Small Size and Flexibility*



### **CLASS Z RELAY:**

Though small and lightweight, this relay is designed for service where flexibility is the more important consideration. For all its compactness, it has adequate coil volume to permit slugging for long operate and release timing. There are four types for d.c. operation, one for a.c., and two with snap-action contacts.

*Special Feature*

### **SPECIAL-PURPOSE RELAYS:**

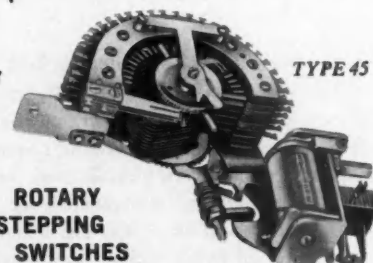
The following types of relays are available for special design problems: Mechanical-Locking Relays; "Micrometer-Adjusting" Relays; Video Relays for frequencies up to 60 megacycles; Bar Relays for the simultaneous closing of up to 35 circuits; Power Relays with carrying capacities up to 25 amps at 24 volts; Oil Dashpot Relays.

*Automatic Control and Telemetering*



**TYPE 44**

A small switch with a large, flexible capacity. For use in almost any d.c. application—for impulse-controlled response that's swift and sure—for self-interrupted operation that's smooth and trouble-free. Accommodates up to six 10-point levels.

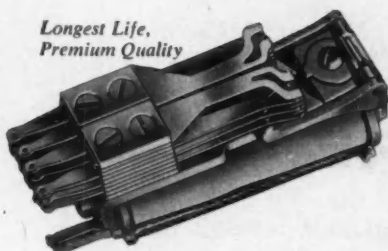


**TYPE 45**

### **ROTARY STEPPING SWITCHES**

Larger capacity: 25 points, 12 levels; 50 points, 8 levels. For any d.c. voltage up to 110, or for 115 volts a.c. with rectifier. Operation can be either impulse-controlled or self-interrupted. Available also as pre-wired hermetically sealed units.

*Longest Life,  
Premium Quality*



#### **CLASS B RELAY:**

Designed to provide hundreds of millions of dependable operations under all mounting and service conditions, with unfailing contact reliability. Extremely sensitive, twin-contact type, with long or short armatures. Has a wide range of practical timing, will withstand extremes of temperature. Finest telephone-type relay available.

*Rugged, Miniature  
Type*



#### **CLASS E RELAY:**

For designs where space is at a premium. Embodies most of the features of the Class B relay, with a life of 200 million operations or more. Twin contacts insure contact reliability. Ideal for small-size computer applications, and where weight and space reduction for portability is of prime importance.

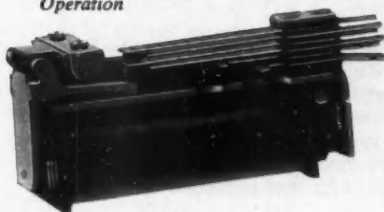
*General Purpose*



#### **CLASS A RELAY:**

This all-purpose relay—sturdy and dependable—can be mounted in any position, and provides long life and reliable operation with only occasional adjustment. The original "work horse" telephone-type relay—recommended when the extreme degree of life and reliability provided by the Class B relay is not mandatory.

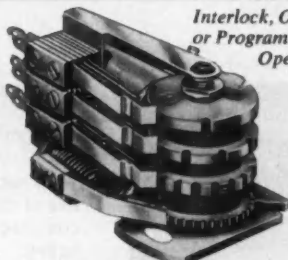
*Alternating-Current  
Operation*



#### **CLASS F RELAY:**

For use on a.c. only, from 16 to 66 cycles. This class of relay does not offer operate or release time delays as the d.c. classes do. Types are available with spring contacts, snap-action contacts, and mercury contacts. All types will handle heavy a.c. loads with small controlling currents.

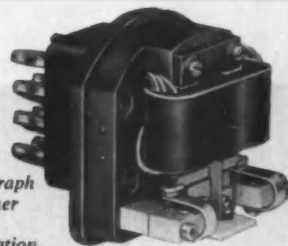
*Interlock, On-Off,  
or Program-Cycle  
Operation*



#### **SERIES OCS RELAY:**

A far superior alternate to an interlock relay wherever shock, vibration or field maintenance difficulties may arise. The main feature is its use as a programming relay that can follow or initiate a prescribed series of events or cycles, and is, therefore, particularly useful in solving automatic-control problems.

*Telegraph  
or other  
Polar  
Operation*



#### **SERIES PTW RELAY:**

For high-speed response to polarized pulses. These relays provide maintenance-free service in telegraph-pulse-repeating operation, such as teleprinter and digital data transmission circuits. Their tungsten-carbide contacts provide billions of operations in normal service. Operate time is less than 0.001 sec., contact bounce less than 8%.

**MAKING IDEAS**

**WORK AUTOMATICALLY**

**SPECIAL SERVICES**—If you have a problem in automatic control, AE can supply completely wired and assembled control packages designed to your specifications or help you develop entire systems. For more information write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Ask for catalog on Relays and Switches for Industrial Control and new 32-page booklet on Basic Circuits.



# **AUTOMATIC ELECTRIC**

Subsidiary of  
**GENERAL TELEPHONE & ELECTRONICS**



CIRCLE 21 ON READER-SERVICE CARD

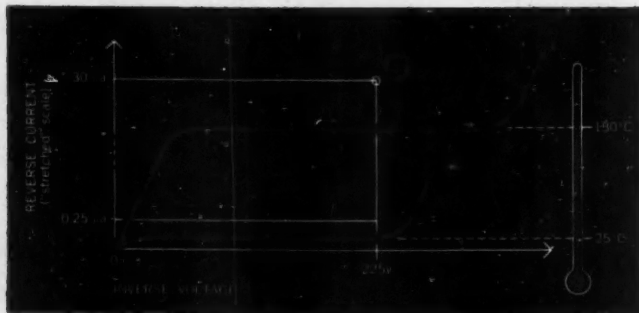
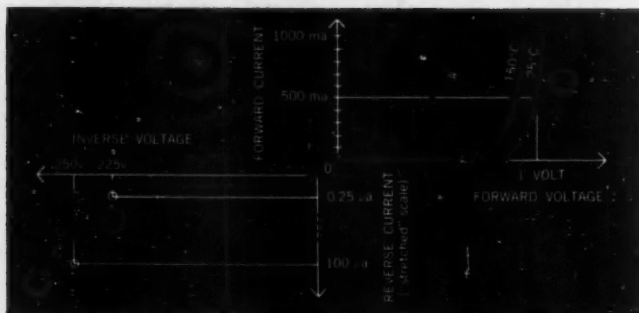
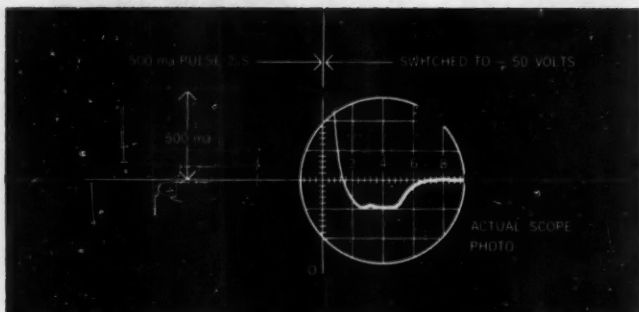
AUGUST 1959

21

# 1/2-AMPERE FAST



# SWITCHING DIODE



**NEW FROM SPERRY** is this high-temperature IN690 series silicon diode which gives you greater current-handling capability than germanium diodes — *with no sacrifice in recovery time!*

Check for yourself the performance characteristics of this new diode in the graphs at left . . . then compare them with our *minimum* specifications below.

● **FAST RECOVERY.** Maximum recovery time is 0.8 microseconds to return to 10 K ohms. Recovery test switches from a forward current 2 microsecond pulse of 500 ma, to a reverse voltage of -50 volts with a loop impedance of 1 K ohm.

● **HIGH FORWARD CONDUCTANCE.** The forward current specification is 400 ma at 25° C with 1.0 volt maximum drop under static (d-c) conditions. Conductivity increases with temperature — diagram shows typical "x-y" plots at 25° and 150° C.

● **LOW LEAKAGE** at high inverse voltage. Specification at 25° C is maximum 0.25  $\mu$ a at rated voltages.

● **HIGH INVERSE VOLTAGE.** Saturation voltages can be supplied in a range from 40 to 150 volts for this high current series.

● **HIGH-TEMPERATURE OPERATION.** Typically, leakage current is no greater than 30  $\mu$ a at working inverse voltage and 150° C. Diodes are rated for both operation and storage at temperatures from -65° to +150° C.

**SPERRY SEMICONDUCTOR DIVISION**  
SPERRY RAND CORPORATION  
South Norwalk, Connecticut

**ADDRESS ALL INQUIRIES:** Marketing Department, So. Norwalk, Conn., or Sperry offices in Brooklyn, Cleveland, Seattle, San Francisco, Los Angeles, New Orleans, Boston, Baltimore, Philadelphia.

### Joint Control Meeting for Boston

**Boston**—First joint-society meeting on control systems engineering has been scheduled by a special steering committee appointed by the American Automatic Control Council. The pioneering session will be held on the MIT campus in Cambridge (Mass.) on September 7, 8, and 9, 1960. Cooperating societies: ISA, IRE, AIChE, and ASME.

### British Petroleum Buys Computer

**London**—British Petroleum Co., Ltd. has ordered a control engineering research electronic simulator from Air Trainers Link, Ltd. for installation in the company's refineries and technical department. Simulator will be used to reproduce conditions on refining apparatus so that new automatic control systems can be studied.

### Whirlwind I Looks for a New Home

**Cambridge, Mass.**—Whirlwind I, the granddaddy of all digital computers, has been retired by MIT at the ripe old age of eight—a victim of obsolescence. Compared to today's solid state machines, Whirlwind is too slow, cumbersome and expensive to maintain. As the first digital computer, it could handle 20,000 arithmetical operations per second using 16-bit characters. Mean free time between errors was over 200 hours. When the machine was first built under contract to Office of Naval Research, it had an electrostatic memory with a capacity of 32,768 bits—2,048 characters of 16 bits each. However the memory averaged an error or two a day, was finally replaced by the first magnetic core memory in 1953. It took core supplier General Ceramics Corp. 11 months to supply the 100,000 cores for the memory. At that time, the company had to make 500,000 to get 100,000 usable ones. Government agencies are now being canvassed to determine whether any of them have a use for Whirlwind. If nobody in government wants it, the machine may go to a private organization or a friendly foreign country.

### Electronic Control for Cement Kilns

**Riverside, Calif.**—First large-scale (50 loops) installation of Foxboro's solid state electronic process control (Electronic Control Instrumentation) is undergoing installation checkout pains at Riverside Cement Company's Oro Grande (Calif.) plant. Applied to two new kilns, the Foxboro units represent a major innovation in the cement industry. One major job of the control is to regulate the temperature of kiln material while automatically maintaining proper combustion through oxygen control and operation of the clinker cooler. Twenty control loops are involved in controlling temperature of the two kilns. To regulate the amount of secondary air down into the kiln, a predetermined fuel-air ratio is maintained by controlling the speed of the draft-fan. When an operator changes the fuel setting, the fan speed changes proportionately. Eventually the electronic control will be tied in to a Thompson Ramo-Wooldridge RW-300 computer which will be used to solve equations relating to the composition of materials and to adjust the operation of the kilns.

### Remote Gas Turbine Power Station

**Vancouver, Can.**—B. C. Engineering Co., Ltd. is building the first automatically controlled gas turbine installation in the world. Four 25-megawatt turbines will be installed at Port Mann, Canada. The plant will be fully automatic, unattended, and remote controlled by supervisory control and telemetering equipment. Signals will be transmitted both by land line and microwave from the control room in the B. C. Electric head office, 15 miles away.

### Automatic Warehouse for Colgate

**Kansas City, Mo.**—A punched card run warehouse is being built for soap maker Colgate-Palmolive-Peet Company. General Electric will supply the control equipment, having won the contract in spirited competition with IBM.

# advanced PRECISION COMPUTING RESOLVERS for Cascaded Resolver Systems

## SIZE 8 FEEDBACK WINDING RESOLVERS



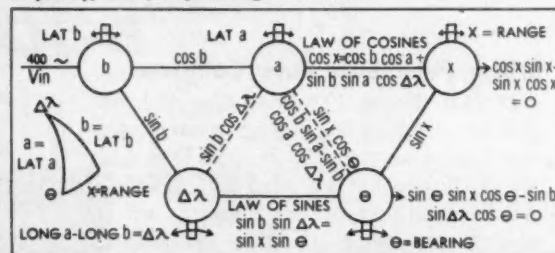
These resolvers are designed for use with transistorized amplifiers and permit the solution of spherical triangles in a size 8 cascaded resolver chain.

Functions of the spherical triangle which can be produced are indicated in the schematic below. More complex trigonometric functions, as well as systems involving coordinate axis transformation, can be generated with the use of these resolvers.

Accuracy: Functional error .1% or less; winding perp.  $\pm 5'$ . Electrical

characteristics: Input voltage 15v400~ (stator); output voltage 13.7v (rotor); phase shift (stator as primary) 20.5°; output voltage

13.7v (compensator); Zro 234 + j596; Zso 244 + j548; Zcompensator 237 + j553; max. null voltage 1 mv/v.



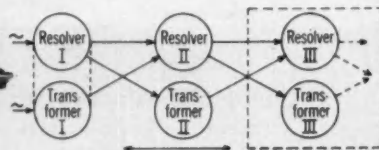
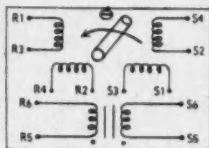
## SIZE 11 AMPLIFIERLESS RESOLVER FOR ANGULAR DATA TRANSMISSION



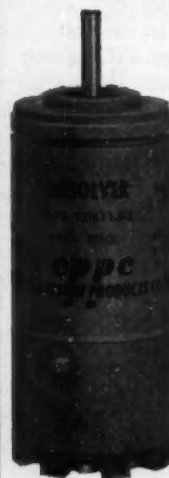
These size 11 resolvers incorporate an integral transformer which simulates a resolver function at maximum coupling. They are used in the typical chain application indicated below for angular data transmission. In this particular application, the output information can be served at either end of the chain.

Quick disconnect allows ease in harnessing.

Accuracy:  $\pm 5'$  of arc or less; winding perp.  $\pm 5'$ . Electrical characteristics: Input to EITHER rotor or stator. Input voltage 115v1600~; output voltage 110v both stator and rotor as primary; phase shift (stator primary) 1.1°; phase shift (rotor primary) 1.9°; Zso (nom.) 990 + j13500; Zro (nom.) 1150 + j13500.



## SIZE 11 RESOLVER TRIMMED FOR ZERO PHASE SHIFT CONTAINS ALL COMPENSATION IN 2 1/4" LENGTH



The YZC-11-E-1 precision computing resolver has been developed for use in a cascaded, amplifierless resolver system at 900~.

These units have been trimmed to provide zero phase shift and compensated for transformation ratio stability, under temperature, when working into their iterative impedance.

Accuracy: Functional error .1% or less; winding perp.  $\pm 5'$ . Electrical characteristics: Input voltage (stator) 40v900~; output voltage (rotor) 33.2v; phase shift 0; max. null voltage 1 mv/v.

Also ready for delivery is an equivalent, compatible pancake resolver. By its use, differential information from an inertial platform may be obtained and introduced into the system.

ENGINEERS—Join the leader in the rotating components field. Write David D. Brown, Director of Personnel, Dept. N8

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# Clearing the Troubled Air

**Interference of electronic devices is worrying the U.S. Army. The Signal Corps is setting up a multi-million dollar installation of instrumentation and data acquisition equipment to study equipment compatibility under actual field conditions.**

## FORT HUACHUCA—

On a sun-baked stretch of Arizona desert and mountainside covering 270 miles, the U.S. Army Signal Corps will soon start building a unique outdoor maneuver area called the Electronic Environmental Test Facility. Its purpose: to obtain detailed information about the radiation emitted by Army electronic gear and the susceptibility of electronic systems to radiations emitted by other systems

operating nearby. The new facility will be part of the U.S. Army Electronic Proving Ground here.

The Signal Corps' grave concern about electronic compatibility points out an increasingly harassing fact of modern life: it is getting tougher to find a place free of man-made electronic interference. To Army planners, growing more dependent on electronic devices every year, the answer is crystal clear: learn more about interference or stop developing new electronic devices.

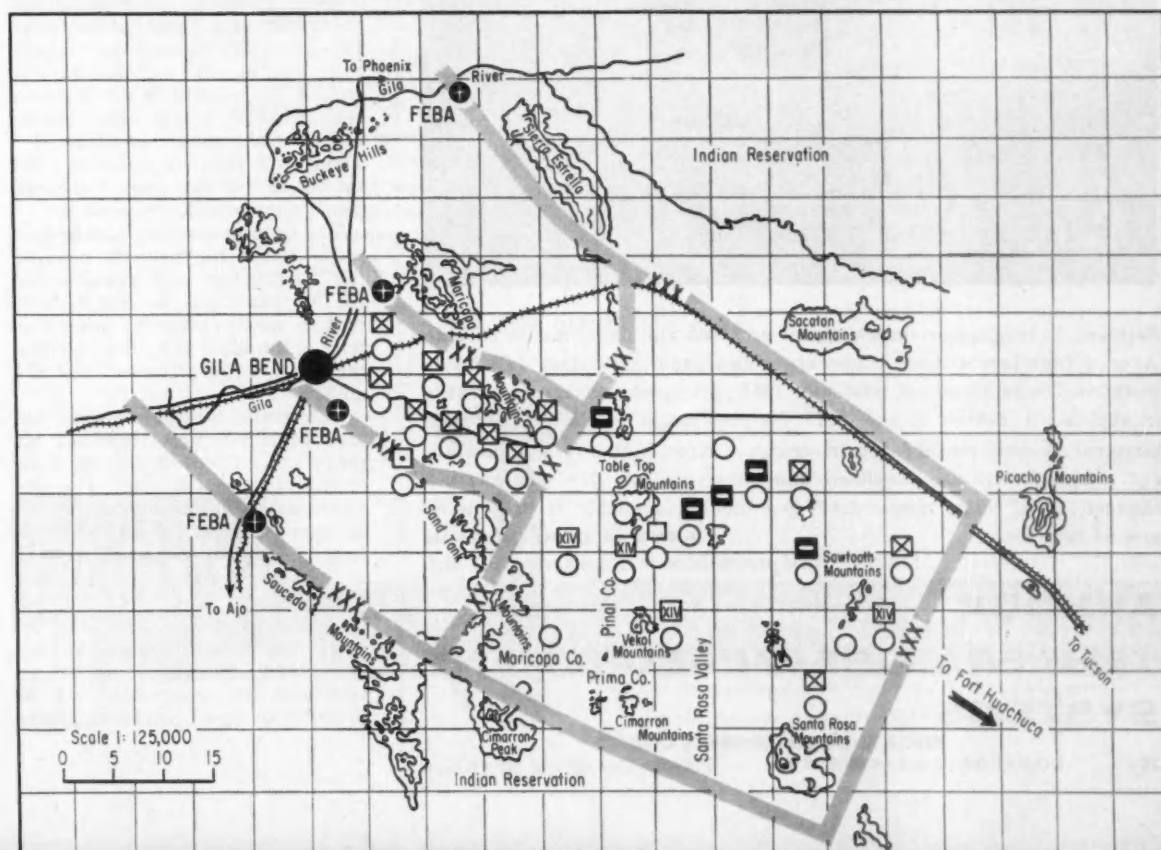
•**Crowded military air**—Army units are already using electronic equipment for communications, enemy surveillance, weather forecasting, data processing (CtE, July '59, p. 25), missile guidance, target location, fire control, and radio jamming. In fact, an Army Corps (composed of three Pentatomic divisions) in the 1960's will use over 15,000 electronic devices—jammed into an area only 60 miles by 60 miles. On top of this, the enemy can be expected to unleash electronic countermeasures to confound the

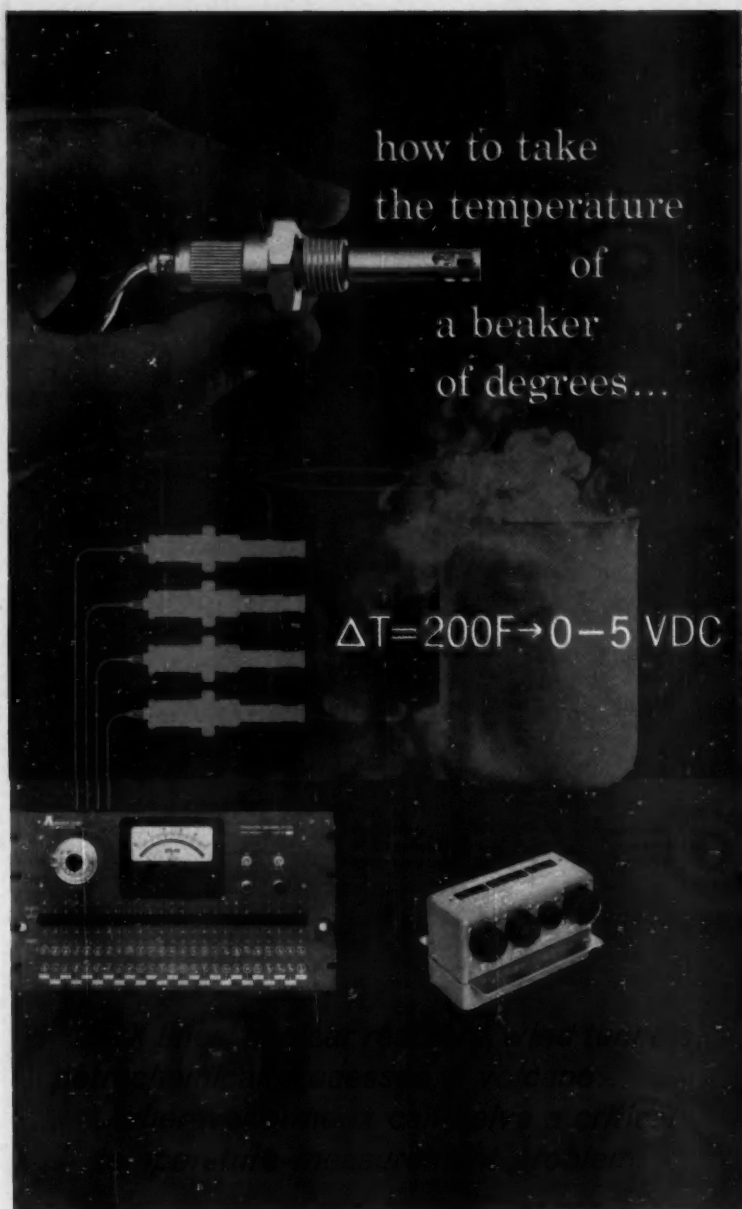
Army's electronic gear. And the Army will reciprocate with its own repertoire of countermeasures.

This density creates an electronic environment in which each device may receive hundreds of undesired signals competing with the desired one, and many of these will have sufficient strength to create noise or disturbance.

•**Significant interference**—Function of the EETF is to supply a highly instrumented area closely resembling the military environment in which this equipment will operate. All the devices of a Corps will be deployed—or simulated—so they can produce their normal radiation frequencies, patterns, and effects. Then the effects of this electromagnetic radiation will be measured and recorded so that "significant interference" can be isolated and identified.

The term "significant interference" represents a new factor contributed by the proving ground. It means a degree of interference that is objectionable. The big problem is putting





Solutions to temperature-measurement problems are not so elusive once an Arnoux high-level-output temperature-measurement system (TME) is installed. The multichannel, solid-state TME, a complete package, is versatile in application, flexible in use. TME features range selection, expandable temperature span, recalibration in seconds...direct high-level-voltage read-out...dc amplifiers are completely unnecessary; result: low, low cost per channel...total range from -320F to +1000F...available in airborne or ground versions.

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PHONETICALLY, SAY ARE'NEW

## TEMPERATURE-MEASUREMENT SYSTEMS

CIRCLE 26 ON READER-SERVICE CARD

CONTROL ENGINEERING

## WHAT'S NEW

numbers on significant interference, something that will be the object of a fundamental study soon after EETF starts operating.

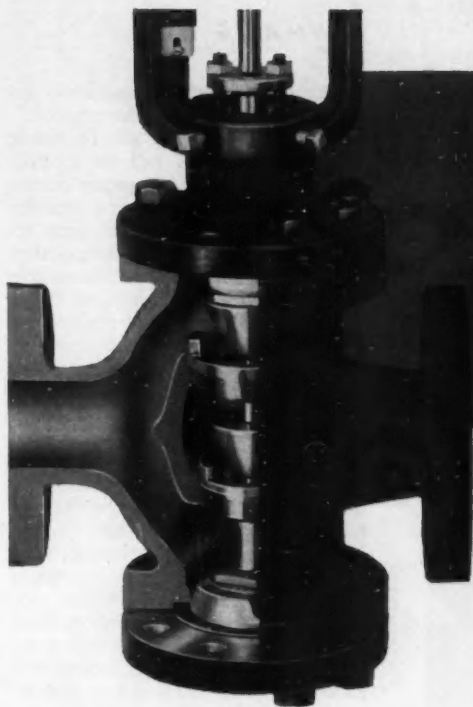
Harmonics of frequencies are the worst trouble makers, according to D. K. Adams, chief plans branch, planning and development div. at Fort Huachuca. A radio transmitter, for example, operating at 800 kc, would also be sending out weaker signals of 1600 and 2400. Two transmitters operating together at different frequencies might not cause any trouble, says Adams. But put them close together and the harmonics of each could develop a third frequency that would raise merry hob with all the electronic devices in the area.

• **New instrumentation** — Another major headache is devising new instruments to detect and measure significant interference. Huachuca's Adams expects that such instruments as precision slotted line and VSWR indicators will be the workhorses. These can be used to measure standing wave ratios, impedance, fundamental and harmonic frequencies, relative power, and attenuation loss in transmission lines over the frequency range of 100-3000 megacycles. Nobody, however, is willing to guess how many new instruments will have to be developed for range.

EETF's buildup has been planned to stretch over five years. At the end of two years, the Signal Corps expects to be able to make sufficient tests to try out the concept of an electronic environmental testing area. Studies will be made in the magnitude of a company or battalion operation. But by the end of five years the Signal Corps plans to make full scale tests.

The Corps is currently looking for a single civilian contractor to supervise the construction and operation of EETF. Plans call for first tests to start six months after this prime contract is awarded. It's estimated that the first two-year phase will cost \$24 million.

• **Electronic combat area** — For full scale operation, Fort Huachuca has staked out a Corps' typical operating territory (see tactical map). The plot encompasses all kinds of terrain: desert, bare mountain ridges, and valleys covered with heavy vegetation. In it, at suitable locations, all the electronic devices used by the Corps will be placed to establish the same dynamic environment as found in combat. Those devices that are too expensive to be incorporated will be simulated by signal generators, chosen



**C<sub>v</sub> COMPARISON TABLE**

Valve Size	K&M	Valve B	Valve C
1/2"	10.9	8.0	8
3/4"	17.3	14.0	14
1"	39.1	30.0	30
1 1/2"	61	47	47
2"	97.7	71.0	71
2 1/2"	150	110	110
3"	219	165	165
4"	500	350	350

Based on flow through 1" diameter hole through 1/2" and 1" valves. Pressure drop across valve is 100 psi. See Bulletin CV53 for details.

## K & M GIVES YOU THE MOST VALVE FOR YOUR DOLLAR

### averaging highest in C<sub>v</sub> ratings

When you are buying control valves, one of the most important points to consider is flow capacity, or C<sub>v</sub>. Valves of the same nominal size won't necessarily deliver the same flow output, which is what you're paying for.

K & M valves give you the highest C<sub>v</sub>'s available. This is not an extravagant claim derived from estimates or theoretical calculations; it is based on actual hydraulic tests.

The accompanying table will show you just how much higher is K & M's flow capacity. Sometimes, this greater efficiency permits the use of the next smaller size valve—at a substantial dollar saving. Always, it provides better controllability: fluid flow is smoother, less turbulent, with lower pressure loss through the valve body.

With K & M, you get what you pay for—and then some.

**SEND FOR BULLETIN CV53.**

# K&M

diaphragm control valves

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G.A. 1904

CIRCLE 27 ON READER-SERVICE CARD

AUGUST 1959

27

# how HIGH is "high reliability"?



## here's sheer torture for a Pot!

**PROBLEM:** Preco Inc. needed a high reliability, pendulum-actuated sector potentiometer for its Automatic Blade Control to serve as the reference for controlling the transverse slope of the cutting blade in road-grading equipment. The pot would be subjected to operating conditions rarely encountered even in the most severe military applications. In addition, no technical assistance would be available for maintenance or replacement.

**SOLUTION:** Using precious metal alloy wire, a specially formed mandrel and a precious-metal wiper assembly, Fairchild engineers developed an extremely high resolution pot which has performed effectively through more than 30 million cycles with a linearity of 0.15% and a resolution of 0.5 miliradian. Another example of Fairchild ability to custom tailor precision potentiometers and sensing devices to solve complex problems over a wide range of applications.

### CUSTOMER'S TEST RESULT

Other designs failed after only  
2 months' wear  
FAIRCHILD'S POT has exhibited  
an equivalent of 5 to 10 years' life



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CIRCLE 28 ON READER-SERVICE CARD  
CONTROL ENGINEERING

### WHAT'S NEW

to carefully reflect the radiation frequency and pattern of the original.

Throughout the test area 18 mobile monitoring stations will be spotted. Each will contain measuring instruments to detect the necessary variables (all of which have not yet been selected). Each will record its collected data on magnetic tape at the mobile unit as well as transmitting it by microwave to the central control station at Fort Huachuca. As a starter, mobile facilities will carry telemetry units, engineering test units, frequency monitoring units, radar units, communication units, and signal simulators—all of a conventional design.

Instrumentation is expected to be developed in three stages. In the first phase—described above—the instrumentation will be fully manned, with no special provision for automatic scanning data readout, or remote control. Two types: 1) general purpose units with great sensitivity and wide coverage, and 2) smaller units with coverage limited to spectra of particular interest and with higher frequency and directional resolution within the chosen bands.

In the second phase, high speed frequency scanning and semi-automatic operation will be added to provide broader coverage of the simulated electronic-order-of-battle. In the final stage, airborne monitors, with special data handling and storage provisions will further increase capabilities.

• **Collecting the data**—During a test, two kinds of data will be collected. First, EETF will measure the response or output of equipment under test—such variables as peak power, antenna pattern, and spurious radiations. This information will be compared to operating characteristics for the equipment measured during a test in which the equipment is isolated from other electronic devices. The result will show how the environment affects the operation of the gear.

Second important data is how the equipment understudy influences the characteristics of the environment.

Huachuca's planners envision a test setup which will permit them to stop any objectionable interference as soon as it is identified. They'll do this by shutting off each of the 15,000 devices in the test area in turn, and measuring its effect on the one device under test. To do this tremendous job, Huachuca will use a magnetic tape to program the entire test. During a run, the sequencing operation will stop as soon as significant interference is detected.

—Lewis H. Young



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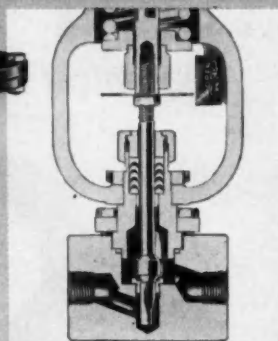
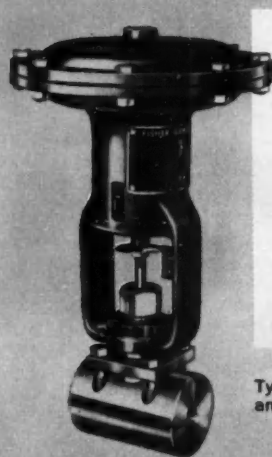
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LEADING INNOVATOR AND PRODUCER OF ADVANCED ELECTROHYDRAULIC SERVOVALVES

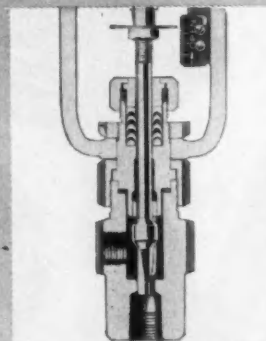
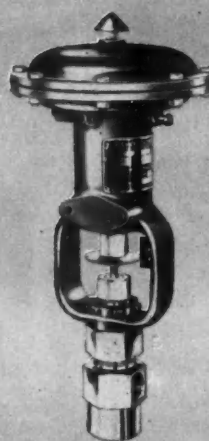
# "Hand size" control valve for all corrosive applications

- ▶ Inexpensive and highly dependable.
- ▶ Available in globe or angle body single port construction.

Fisher now offers the low cost, dependable "BA" angle body and the "B" globe body valves for use on heavy duty applications involving corrosive liquids. Bodies are machined from 316 stainless steel bar stock, or other alloys such as Monel or Hastelloy. Either body can be supplied with Type 510 spring open or Type 511 spring closed diaphragm actuator. Normal diaphragm range 3 to 15 psi.



Type 510-B valve with globe body and bolted bonnet construction.



Type 511-BA valve with angle body and a union nut bonnet.

## CONSTRUCTION AND SPECIFICATIONS

Valve Body Sizes	$\frac{1}{8}$ " $\frac{3}{8}$ " and 1" only with screwed end connections.
Inner Valve	Micro-flute or Micro-form.
Orifice Sizes	$\frac{1}{8}$ ", $\frac{3}{8}$ ", $\frac{1}{2}$ " and $\frac{3}{4}$ " for the 1" size body. $\frac{1}{8}$ ", $\frac{3}{8}$ " and $\frac{1}{2}$ " for the $\frac{3}{8}$ " size body. $\frac{1}{8}$ " and $\frac{3}{8}$ " for the $\frac{1}{8}$ " size body.
Max. Body Pressure	1500 psi at 450° F.
Overall Dimension	Approximately 15" with the Type 510 or Type 511 topwork on either a "B" or "BA" body.

For complete information  
write for Bulletin 57 B.



IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD ... CHANCES ARE IT'S CONTROLLED BY ...

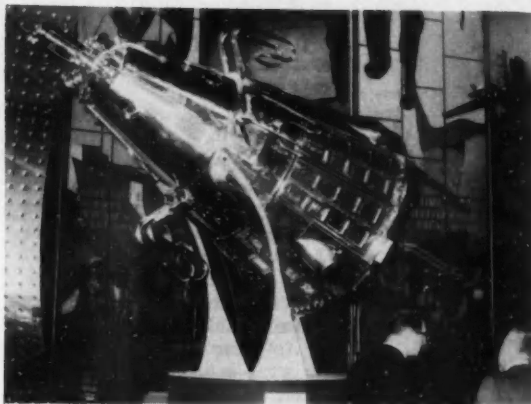
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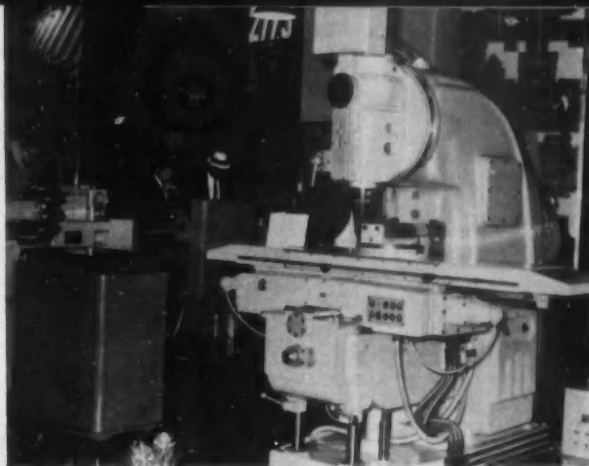


SINCE 1880



#### Cosmic Probe

Pride of the Russian exhibit is a display of space vehicles. Replica of the sputniks can be seen as well as this duplicate of the cosmic probe which went into orbit around the sun last January. (Its control system was described in CtE, Feb. '59, p. 68.) A recorded talk accompanies the display.

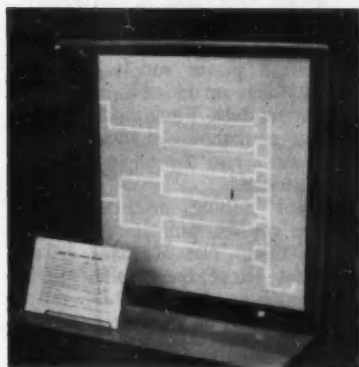


#### Magnetic Tape Control

Compact box at left contains numerical control system to direct the three-axis milling machine shown here. System is open loop because the Russians feel closed loop control is too complicated for mass production. 10 of these numerically controlled mills have been built; the Soviets plan large scale production.

#### Automatic Synthesizer

Contact circuit synthesis machine automatically develops type I and K poles in contact circuits according to predetermined operating conditions.



## A Russian Spectacular Opens in New York

Giant Soviet exhibition in New York is a sight worth seeing. It is heavy on instrumentation, light on controls. In addition, the consumer goods displays, the models of factories, and the atmosphere of Russian life should interest engineers.

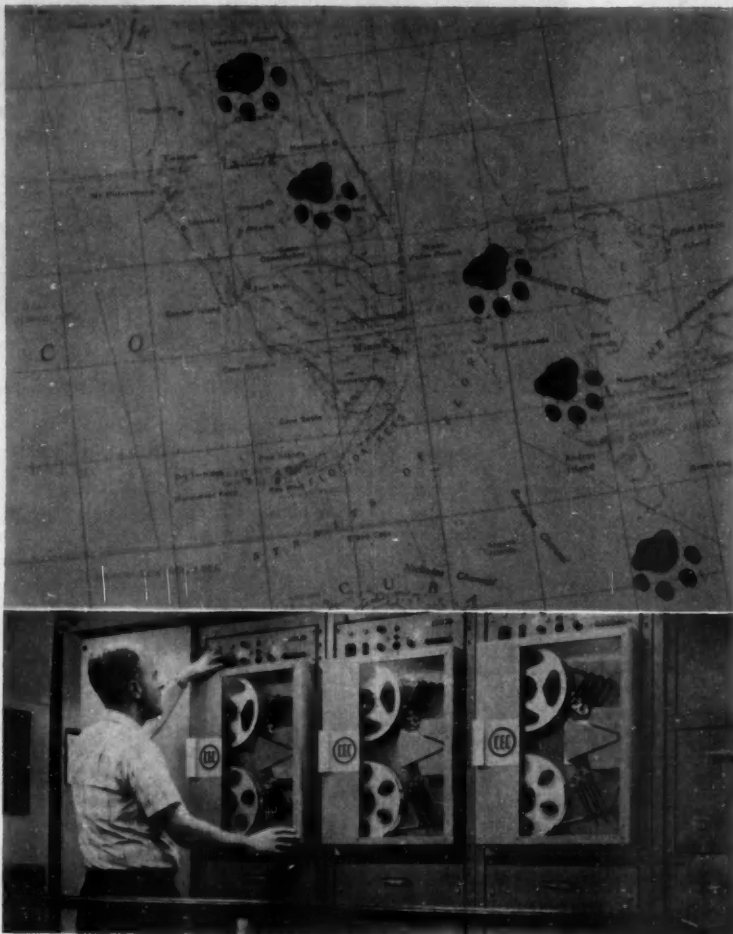
NEW YORK—

A newspaperman misquoted Soviet Exhibition chief A. N. Manzhulo. The journalist cited the cost of the Soviet Exhibition (which opened on June 30, will run to August 10) as \$12 million. What Manzhulo had actually said was the show cost 12 million rubles or 3 million dollars. But the original figure of \$12 million

#### Air Traffic Controller

Handsome console for air traffic control at airports represents a Soviet "what might be" product. Equipment has built-in two-way communications. Scopes in the center are radar screen (left), glide path for instrument landings (center) and slope of glide path (right). Behind the console can be seen a model of a proposed airport tower.





**THE FINE ART OF TRACKING** and recording data from the nation's newest missiles is the task of the newly outfitted USS American Mariner—operating in the waters of the Atlantic Missile Range. Advanced electronic equipment aboard includes CEC DataTape 5-681 Digital Recorder/Reproducers. Employing all solid-state electronics, the units feature 5-millisecond start and stop times, 0.05" tape positioning accuracy, 10½" NARTB reels, and complete front accessibility. Transport fits standard 19" relay rack. Two types provide tape speeds to 30 and 150 ips. For more information, call your nearest CEC sales and service office, or write for Bulletin CEC 1618-X6.

*DataTape Division* **CEC**

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**CIRCLE 32 ON READER-SERVICE CARD**

**CONTROL ENGINEERING**

## WHAT'S NEW

might very well have been correct if the Russians had not brought a lot of displays from the World Fair in Belgium. The Soviet Exhibition is one of the most spectacular exhibits ever held in the New York Coliseum (see photos, page 31).

With over 10,000 individual displays, the Russians have tried to present a slice of Russian life. One problem to American visitors is how to separate what actually is from what the Soviets would like to be. Just by looking, it is impossible to tell a prototype from a production item. For example, on display is a magnetic tape controlled, three dimensional milling machine. By cross-examining a Russian attendant, CTE learned that only five units of this design had been built.

Although the instrumentation and control exhibits took up only a small part of the six acres of show, a number of interesting devices were on display. Here's a thumbnail sketch:

- Relay circuit analyzing machine, the first one ever built in the Soviet Union, cuts relay design time.

- An analog computer that requires no stabilized power supply. Operational amplifiers are added in modules, four to a module. Functional generators use germanium diodes. Non-linear sections and the power supply are transistorized.

- Vertical milling machine with open loop control, programmed with magnetic tape. The Russians have built about 10 of these, plan large scale production. A closed loop profile machine, also on display, will not be produced in large numbers; its control is too complicated.

- Air traffic control console with a demonstration of how it is used. There is considerable doubt however, if there is a single such installation anywhere in Russia.

- Radioactive thickness gages used to measure the thickness of paper.

- Laboratory instruments including a quantometer which could pass as an American design for special analysis of alloys, an ultra-taumeter which the Russians said was an entire laboratory for the study of luminescence and photoconductivity, a steelscope for the rapid visual qualitative spectral analysis of steels.

The Soviet Exhibition opened with rave reviews: Over 40,000 people toured it the first day. If you are in New York before August 10, the show is worth seeing. Admission is one dollar. The exhibit is open from 11:00 am to 10:00 pm, except Sunday when the hours are 1:00 to 8:00 pm.

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TWO FORWARD STEPS  
IN VOLTAGE REGULATION  
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Over four years of development, design and improvement of manufacturing methods in the Sola labs and plant have finally resulted in two advances in the voltage regulating field:

A new "standard" Sola Constant Voltage Transformer provides famous Sola  $\pm 1\%$  regulation, along with SINUSOIDAL OUTPUT AT NO PRICE PREMIUM OVER OTHER MAKES OF STATIC-MAGNETIC REGULATORS.

Many "normal-harmonic" types of the Sola CV have been REDUCED IN PRICE, thus opening to you the benefits of supply voltage regulation in new fields where cost has heretofore been a deterrent.

The new Sola Standard Sinusoidal Constant Voltage Transformer affords all the proved benefits of a static-magnetic regulator. It provides output voltage regulation of  $\pm 1\%$  for line voltage variation as great as  $\pm 15\%$ . It provides completely automatic and continuous regulation, with output having less than 3% rms harmonic content.

In addition to the improved output wave form, the new design is substantially smaller and lighter than previous models. Because of design and production innovations, it is relatively compact compared to other equipment for comparable ac voltage regulation. It costs about the same as previous models which did not have sinusoidal output. This sine wave output feature at such a low cost permits use in many applications requiring harmonic-free input where previously the cost was prohibitive.

The sinusoidal output feature contributes to ease of selection and ordering. The buyer merely selects the stock unit whose output capacity equals or exceeds the desired equipment input. Formulae based on sinusoidal wave shape may be used in designing related load

... please turn page

Manufacturer of specialty transformers and other electro-magnetic devices

(Advertisement)

... continued from preceding page

circuitry. The Sola Standard Sinusoidal CV Transformer is available in nine stock output ratings from 60va to 7500va.

The "Normal-Harmonic Type" -- the familiar "Sola CV" -- had become the "standard of the industry" for static-magnetic voltage regulation by virtue of its outstanding performance for over fifteen years. Now it, too, has been given a comprehensive re-design treatment which has yielded the same kind of weight and size reduction secured in the new sinusoidal type -- and without sacrificing the performance for which it was widely recognized.

Cost savings from this four-year program of refinement are NOW PASSED ON TO YOU in the form of appreciable price reductions on many of the most popular ratings. You can now consider the benefits of closely-regulated supply voltage for your equipment at less cost than ever.

With electrical control systems and components continuing to increase in number and complexity, and imposing more rigid reliability requirements, these new Sola Constant Voltage Transformers provide many advantages and virtually unlimited application. They are ideal where utmost reliability is required, with no transformer maintenance.

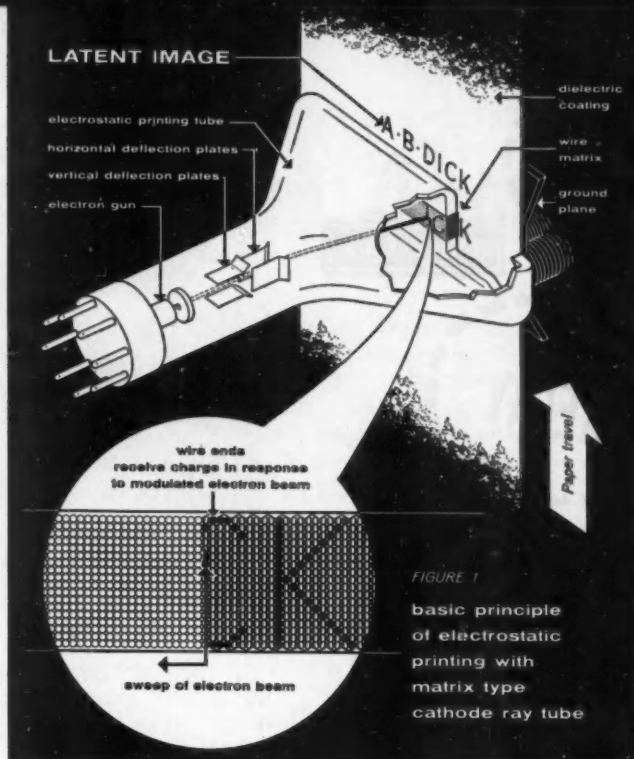
We would welcome the opportunity to provide you with more detailed information. Please write for Sola Product Bulletins for data on our stock models. Or write or call for full information on custom units for specific requirements, available in production quantities. Your request will be promptly handled.

Sincerely,

SOLA ELECTRIC CO.

*Nelson P. Marshall*

Nelson P. Marshall  
General Sales Manager



## Unique Printer Spews Out Data

*A revolutionary printing process, using a television tube with a wire matrix in its face, prints out at rate of 10,000 lines per sec, or 20,000 characters per sec.*

A high-speed electronic process capable of translating computer language into a display or hard copy at the rate of up to 20,000 letters, numbers, and symbols per sec, has been developed by the A. B. Dick Co. Named the Videograph process, it can read and translate binary pulses directly from a computer, magnetic tape, or paper tape or directly from punched cards. And it can either print the translation or display it on a television screen.

An additional unique feature of the process is the ability to instantaneously print out pictures of moving objects which pass in front of a specially adapted television camera. As a result, it can be used to scan such objects as moving railroad cars.

• Wires replace the phosphors—The new printer is based on a special cathode ray tube, called an electrostatic

printing tube, developed at Stanford Research Institute in a program that started in 1955. The conventional phosphor-faced screen of the cathode ray tube has been replaced by a matrix of spaced, small-diameter wires fused into its face plate across its major dimension. The inner ends of wire are directed towards the electron gun; the outer are aired to the atmosphere.

Here's how the process prints. First an electrostatic image is created on the printing medium, usually paper. To do this, an electron beam is energized, it strikes the inner ends of the wire so that it conducts electrons through the vacuum wall. These electrons are thus deposited on the paper surface, directly under the point of impingement of the electron beams, as a negative charge pattern.

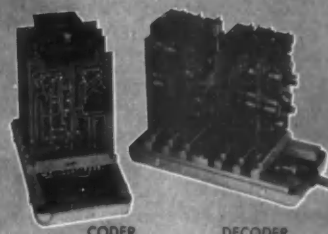
Next the electrostatic image is developed into a visual image and "fixed" to provide permanency. To do this, the paper passes through a mixture of a carrier which is usually charged negatively, and a toner powder which is statically charged to a positive potential. The positively charged toner is attracted by and adheres to the negative charge pat-

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SCANNERS

MONITRON is an electronic scanner which monitors from 8 to 256 on-off or go-no-go input signals. Scanning rates range from 15 cps to 1 kc, meeting the bandwidth requirements of almost any application.



- All solid-state components for years of reliable, maintenance-free service
- Modular, plug-in design for instant replacement and future system expansion
- Fully compatible with existing telephone, telegraph and microwave practice
- Available either in integrated systems or component modules

Anywhere you have need for alarm monitoring, centralized control, or an automatic alarm-and-control closed loop, you'll find that Monitron offers performance advantages over any other system.

Monitron is widely used for supervisory control in pipeline and railroad applications, for microwave alarm systems, in unattended stations, and for PDM multiplexing systems. Other uses include telemetering digital information, converting parallel data to serial data, and time multiplexing of slowly changing or quasi-static signals. Cost is comparable with older-style systems; reliability and ease of operation are way ahead.

For more information:

RESEARCH & DEVELOPMENT • PRODUCTION

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CIRCLE 35 ON READER-SERVICE CARD  
AUGUST 1959

35

← CIRCLE 34 ON READER-SERVICE CARD

# HYDRAULIC

MUIRHEAD

# RELAY

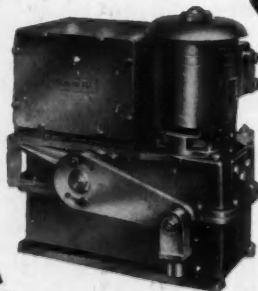
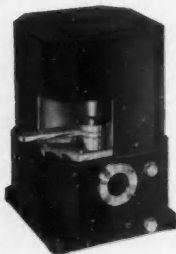
# UNITS

Applications of the Hydraulic Relay Units can be found in the remote control of rolling mills, cranes, elevators, machine tools, furnace regulators in wind tunnels and in remote multiple control of valves in oil blending or the mixture control and weighing of materials. Muirhead engineers will be pleased to discuss the suitability of Hydraulic Relay Units and to advise on methods of installation and control.

Hydraulic Relay Units are made in two sizes (Two stages of amplification):—

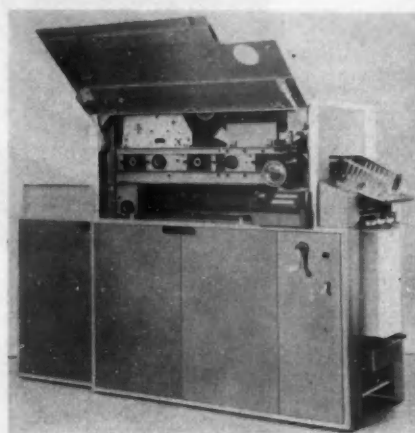
The larger model, type D-696, gives an output torque of 40 lb ft equivalent to 70 lb force acting at the output arm radius of 6-1/2 in through  $\pm 10-1/2^\circ$  in. Typical response time is 0.2 seconds.

The smaller model, type D-881, gives output torques of 4 lb ft, 2 lb ft or 1 lb ft, with response times of 0.3 secs, 0.15 secs and 0.075 secs respectively. The radius of the output arm is 3-1/2 in. Angle  $\pm 15^\circ$ .



Write for details

## WHAT'S NEW



Videograph printer.

tern imprinted on the paper by the electron beam. The negatively charged carrier is repelled. Next the charge is fixed by applying heat which sets the toner to form a permanent black image.

To date, the Dick Company has used a pigmented thermoplastic resin powder for the toner, iron powder as the carrier.

For high speed printing, the paper or other printing medium is transported across the face plate of the tube in a direction generally perpendicular to that of the wire array. For high speed scanning or facsimile reproductions, a special tube is used, one having a single row or array of wires across the face plate. The electron beam sweeps across the single row of wires, synchronized with the horizontal scanning function of the scanning unit. The paper travels past the face plate synchronized with the vertical scanning rate.

• **Applications**—Although the system is brand new, the Dick Company has already sold several installations. A major publisher has bought two units to prepare mailing addresses for magazines. In this application, the Videograph equipment will receive coded information from computer magnetic tapes and then will edit the data to reject unwanted information such as expired subscriptions. The printer will prepare rolls of magazine address labels at the rate of 36 labels per sec., producing 10,000,000 labels per week, replacing 18 machines now working two shifts.

Cost of the new installations range from \$100,000 to \$700,000, depending on the job to be done. Each of the units ordered by the publisher, for example, will cost \$135,000.

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CIRCLE 36 ON READER-SERVICE CARD

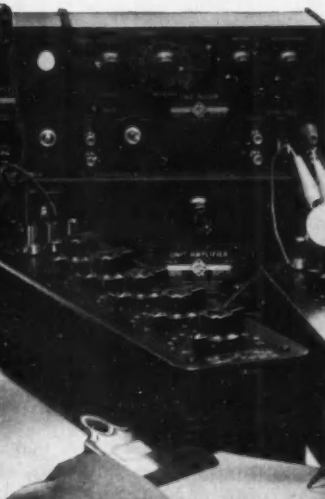
# The Team Approach\*



Infrared systems and other modern-day electronic equipment use many special-purpose transformers having unusual electrical requirements. For example, the small cylindrical transformer shown connected to the decade box was designed by Radiation Electronics Corporation to operate at a primary signal level of  $10^{-8}$  volts. Its primary and secondary impedances are 5 and 50,000 ohms respectively (dc resistance of primary only 0.6 ohm). Bandpass is from 12 cps to 45 kc. To measure these transformer characteristics, a test setup composed of the following G-R instruments is used:

**1603-A Z-Y BRIDGE** (at left) measures transformer impedances in terms of quadrature components at various frequencies and signal levels (transformer input voltage is varied by simply changing the bridge input). This Bridge can be balanced for any impedance from short circuit to open circuit, real or imaginary, positive or negative, over the entire audio-frequency range. Basic accuracy is 1%. Price: \$370.

**1217-A UNIT PULSER** (upper center) provides a means for measuring low-frequency response to better than 0.3 cps — well below the range of conventional audio oscillators. Long-duration pulses are fed to the transformer under test, and low-frequency cutoff is determined by the measurement of the resulting pulse droop. Unit Pulser repetition rate 15c to 100 kc; pulse duration 0.2  $\mu$ sec to 60,000  $\mu$ sec. Price \$235, Power Supply \$40.



Photograph Courtesy  
Radiation Electronics Corp., Skokie, Illinois

\*This group of instruments is useful for the testing of electro-mechanical transducers and audio-frequency devices of all types.

**1206-B UNIT AMPLIFIER** (beneath Pulser) an ideal general-purpose amplifier — 3-watt output from 20c to 50 kc, 1.5 watts from 10c to 100 kc — less than 1% harmonic distortion. Price \$85; Power Supply \$40.

**1432 DECADE RESISTANCE BOXES** provide primary and secondary loads for the transformer under test. Decade Boxes are available in 10 different models in 0.1- $\Omega$  steps to 1000- $\Omega$  steps, total resistances from 111 $\Omega$  to 1,111,100 $\Omega$ . Prices range from \$68 to \$143.

**546-C MICROVOLTER** (extreme right) measures transformer gain and usefulness at very low signal levels. Used with an oscillator, the Microvolter supplies small, accurately-known voltages from 0.5  $\mu$ v to 1.0v open circuit. Basic accuracy is 3%. Price: \$140.

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# NEW!



Model 410  
Full-Wave

## AVION System-Standard MAGNETIC TRIGGERS

for silicon controlled rectifiers

Full-Wave • Model 410    Half-Wave • Model 408

Designed for use with C35, or equivalent, SCRs, Avion Magnetic Triggers feature 1/2-cycle response, virtually zero drift, and exceptional repeatability...

Complete isolation between control-signal and power circuits • high power amplification • precise firing-angle control • multiple control windings

### System-Standard Engineered

Typical Specifications (Model 410-01)

Input: 115V, 50-400 cycles, AC; less than 1.5 watts power required to fire under all rated conditions

Auxiliary control windings provided

Special 400-cycle MIL spec model available

WRITE for prices; also for information on other Avion System-Standard Magnetic/Solid State Products.

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CIRCLE 38 ON READER-SERVICE CARD

38

CONTROL ENGINEERING

## WHAT'S NEW

# At Boeing Nearly Everybody Studies Numerical Control

Over 1,500 employees have taken courses in numerical control because Boeing feels it affects all phases of company operations: from the shop to the finance and sales departments.



White collar workers and shop men sit side by side in Boeing's numerical control courses. Here an instructor shows a part for the 707 jet liner which was milled on a numerically controlled mill.

SEATTLE—

More than 1,500 employees of the Boeing Airplane Company at Wichita, Kansas and Seattle have taken courses in numerical control in the past two years. Students have been drawn from every branch of the company, from production to finance. Two-thirds of them have completed a four-hour course in general familiarization of numerical control; but many of the rest have spent as much as 160 hours learning such subjects as planning and mathematical programming.

"We have found that numerical control affects every phase of our company's operations," says Ed Carlberg, facilities administrator who has worked on the Boeing numerical control program since its inception. "Because NC changes how we buy, purchasing people take the course; because it affects how we inspect, quality control people need some training; because it alters how we bid on contracts, our sales people have to be aware of it; because it affects how we handle our cost accounting, finance people need to know about it; because it increases what our machine tools can do, our design engineers have to get acquainted with NC; and because it affects how we run our shop, our industrial relations people study it."

The Boeing training reflects this tremendous impact. Courses have

drawn students from engineering, facilities, finance, industrial relations, manufacturing, material and quality control, and even top management.

• **General Starter**—General familiarization serves as the starter for all other courses. It also helps to sell the Boeing program to all levels. The company has already installed 14 tape-controlled machines, expects to double that number this fall.

Basic courses, ranging in length from six to 160 hours cover tool design, quality control, use of computers in manufacturing control, and planning and mathematical programming. One course introduces the Bendix tape control system (CtE, June '57, p. 31) to manufacturing and quality control people who have to know about the machine and its functioning but will not have to operate it. Other courses deal specifically with mechanical maintenance, electronic maintenance, and operation of specific machines and control systems.

Boeing tries to keep the size of classes small. Classes in general familiarization may have as many as 30 students, but those of a more technical nature will have as few as six. The courses are taught on company time, in classrooms within the plant. Instructors, from the Boeing training program, are selected for their knowledge of the fields to be taught and are

boost reliability...  
lower noise...  
with the

# extraordinary

## CLAROSTAT SERIES 53



Get the extraordinary low noise, stability and reliability of the Series 53—don't settle for the ordinary. The exclusive Clarostat one-piece carbon contact design completely eliminates the inherent shortcomings of metal-to-metal moving contacts, resulting in lower noise, greater stability and longer life.

If your design deserves the best, specify Clarostat Series 53 molded carbon potentiometers. Write for complete technical details . . .

- Low noise, greater stability, longer life.
- Full 2-watt rating at 70°C.
- Gold-plated terminals molded in place.
- Grease seal around shaft.
- Zero backlash.
- Available in completely encapsulated units for maximum environmental protection.

### SPECIFICATIONS

- ◆ POWER RATING: 2-watts at 70°C
- ◆ RESISTANCE RANGE: Linear—50 to 10 meg. Tapered—250 to 5 meg. (Right or left-hand)
- ◆ INSULATION BREAKDOWN: Between terminals and ground for 1 minute, 1000 v.d.c.
- ◆ SWITCHES: SPST, SPDT, DPST
- ◆ TORQUE: 1 to 6 oz. in. Up to 20 oz. in. with jam nut bushing.
- ◆ EFFECTIVE ROTATION:  $312^\circ \pm 3^\circ$
- ◆ CONSTRUCTION: Meeting requirements of MIL-R-94 where applicable.



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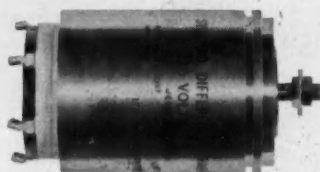
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SIZE 15	CT4b, CX4b, CDX4b, TR4c, TX4b, TDX4b, CT6b, CX6b, CDX6b, TR6a
SIZE 18	CT4b, CX4b, CDX4b, TR4b, TDX4b, CT6b, CX6b, CDX6b, TX6a, TRX6a
SIZE 23	CT4, CT4a, CT4b, CX4, CX4a, CX4b, CDX4, CDX4a, CDX4b, TR4, TR4a, TR4b, TX4, TX4a, TX4b, TDX4, TDX4a, TDX4b, TDR4, TDR4a, TDR4b, CT6, CT6a, CT6c, CX6, CX6a, CX6c, CDX6, CDX6a, CDX6b, TR6, TR6a, TX6, TX6a, TX6b, TDX6, TDX6a, TDX6b, TDR6, TDR6a, TRX6a
SIZE 31	TR4d, TX4a, TX4d, TDX4b, TDR4b, TR6b, TX6b, TDX6b, TDR6b
SIZE 37	TR4a, TX4b, TDX4a, TDR4a, TR6b, TX6b, TDX6a, TDR6a
TYPE 1	1D, 1F, 1HCT, 1HDG, 1HG
TYPE 3	3D, 3F, 3HCT, 3HDG, 3HG
TYPE 5	5D, 5F, 5HCT, 5HDG, 5HG, 5N
TYPE 6	6HDG, 6HG

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**Montrose Division**  
SOUTH MONTROSE, PA.



## WHAT'S NEW

often sent to manufacturers' plants for special instruction.

In some courses, such as the use of computers, Boeing developed its own training material. For other courses, training material was supplied by the control manufacturer, by other companies with numerical control experience, and by actual NC experience at Boeing's operations.

• **Time for programming**—Most detailed course is the one on planning and mathematical programming. Boeing describes it this way: "a study of the specific and detailed information necessary to plan and program a complete work cycle for a numerically controlled machine". It starts with a description of the types of machine tools and their control systems.

Next, the student learns the Boeing engineering drawing system, and how to dimension for numerical control. Problem exercises are solved in manual part programming using a desk calculator. Then the student is ready for the final step: programming a part on the computer. He learns the difference between manual and computer programming and delves deeply into the programming functions.

• **Finding programmers**—Probably one of the most difficult parts of establishing the programming course was selecting qualified trainees. Lyle Mhyre, training supervisor, says "At first, selection was made by shop supervisors who picked men they felt were most qualified. Although standard tests were helpful in determining the level of knowledge of maintenance personnel, the quizzes turned out to be little help in selecting good operators or programmers."

"We came to the conclusion," says Mhyre, "that any intelligent person, well versed in his own field, would fit into the numerical control program."

At the start, Boeing selected programmers from the ranks of mathematicians. Now the company feels no such restriction is necessary. It found that the best programmers are persons with an analytical mind, able to reduce elements to a common denominator.

A good operator of a standard machine will make a good operator of a numerically controlled machine only if you can change his way of thinking, according to Boeing's Mhyre. He says the problem is to convince the operator to live with and work with the new control system. Says Mhyre, "He has to get used to the idea that the program runs his machine now."

—Ray Bloomberg  
McGraw-Hill News

## LOW LEVEL INPUT AMPLIFICATION

- 1,000,000:1 rejection ratio at 60 cps
- floating input
- isolated output

## IN 2 NEW SANBORN CHOPPER AMPLIFIERS

### INDIVIDUAL SET-UPS

portable, self-contained unit amplifier

The Model 350-1500 Low Level Amplifier provides extremely versatile measurement of low level signals through use of two interchangeable plug-in circuits — one for thermocouple applications, another for DC strain gage work (other plug-ins now in development). Floating input and isolated output make the 350-1500 useful when signal measurements are made in the presence of large ground loop voltages. The 10-1/2" high x 4-3/16" wide 350-1500 may be used individually with its own power supply to drive a 'scope, meter, optical element, etc. or as a preamplifier in 6- or 8-channel 350 series recording systems.



### MULTI-CHANNEL INSTALLATIONS

8-unit 7" high modules for  
"850" series direct writers

Compact Model 850-1500A Low Level Preamplifiers are economical, space-saving units for large installations such as aircraft and missile development and test facilities where many recording channels are used to monitor strain gage and thermocouple outputs. Required 440 cps chopper drive voltages can be supplied for up to 16 channels with the Model 850-1900 MOPA.

### SPECIFICATIONS

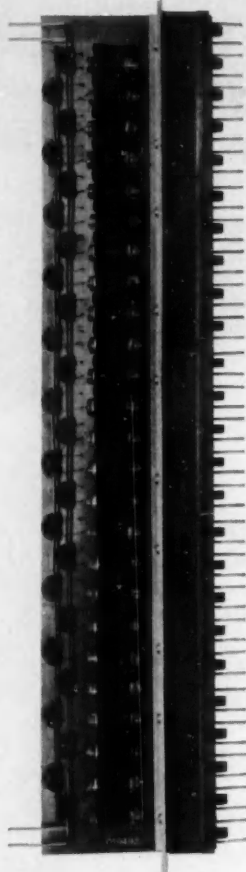
	350-1500	850-1500A
Sensitivity	20 uv input for 1 volt output, or 10 chart div. with Sanborn recorder; X1 to X2000 attenuator	100 uv input for 1 volt output, or 10 chart div. with Sanborn recorder; X1 to X2000 attenuator
Input	Floating, can be grounded	
Input Impedance	100,000 ohms	200,000 ohms
Output	Floating or grounded (independent of input)	
Output Impedance	350 ohms	
Output Capabilities	±2.5 volts across 1000 ohm load	
Bandwidth	DC - 100 cps (3db)	
Linearity	±0.1% of full scale	
Common Mode Performance	120 db for 60 cps and 160 db for DC with 5000 ohms unbalance in source	
Noise	2 uv peak-to-peak over a 0 to 100 cps bandwidth	
Drift	±2 uv for 24 hours	
Gain Stability	±0.1% for 24 hours	

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Complete specifications and application data are available from Sanborn Sales-Engineering Representatives in principal cities throughout the United States, Canada, and foreign countries.

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## SIMPLIFIES COMPUTER/CONTROL CIRCUITS, SHARPLY BOOSTS RELIABILITY

### TDK PARAMISTOR amplifying logic and memory element

*This inexpensive module performs logic and computing functions alike. Capable of self-limiting amplification, it eliminates the need for amplifying and amplitude-limiting circuits. Using only passive components, it provides near-absolute reliability over years of operation... makes possible simple, all-magnetic digital computers and automatic control devices that are virtually maintenance-free.*

*Operating on ac phase relationships rather than dc pulses, the Paramistor uses only about half the power needed for comparable vacuum-tube dc pulse circuitry. Parametric excitation causes the unit's ferrite resonant circuits to oscillate in either of two phases, 180° opposed, providing bi-stable characteristics. A nonlinear reactance buildup provides precise self-regulating amplification.*

*Thoroughly proved, the Paramistor is the product of four years of development at TDK and Tokyo University, and two years of successful application in Japanese industry. It is the key component, for example, in nearly half of Japan's digital computers and in the electronic dial exchange of Nippon Telegraph and Telephone Corporation. TDK is the originator of the ferrite core, and has had more experience in ferrite devices than any other firm in the world.*

*TDK memory core matrices—So that the advantages of the Paramistor may be fully realized, TDK has created inexpensive, highly stable memory matrices for use specifically with the Paramistor. Because of the symmetric dual-frequency TDK principle, variations in individual cores cannot cause misoperation. Reliability is extremely high.*

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**CIRCLE 42 ON READER-SERVICE CARD**

**CONTROL ENGINEERING**

## WHAT'S NEW

### Automatic Testers Speed Jet Autopilot Maintenance

*First airline automatic trouble shooting of aircraft autopilots cuts the time from an average of over four hours to a maximum of 20 minutes.*

SAN FRANCISCO—

For the first time U. S. airlines have started buying automatic inspection equipment to trouble shoot autopilots on the Boeing 707 jet liner. Last month American Airlines took delivery of a California Technical Industries' Supertester Model 100 automatic circuit tester. Trans World Airlines and Braniff Airways have also ordered the devices.

At American Airlines' big new maintenance center in Tulsa, an AA spokesman said the airline expected the new testers to cut trouble shooting time from an average of over four hours to a maximum of twenty minutes.

Until the testers were delivered, when an American Airlines pilot reported trouble with an autopilot, the ground crew pulled the unit out of the plane at the next stop, shipped it back to a central repair point where a skilled electronic technician went over it circuit by circuit. Armed with a vacuum tube voltmeter, he followed down a listing in a book of test specifications, stopping to mark each circuit as he progressed so that he would not lose his place.

If there was one erring circuit in the autopilot, the airlines found it took the technician, on the average, four hours to find it. If there were two, he would average five and one third hours locating both. But frequently there was no trouble at all; then the mechanic spent up to eight hours checking all the circuits.

Using the automatic test equipment, a relatively unskilled mechanic will be able to check the autopilot at major airports—ending the shipment of autopilots to a central point. After it is connected to the autopilot, the unit can perform up to 400 tests in 20 minutes. The book of test specifications is stored in a specially wired adapter which programs the Supertester. Each erring circuit is identified by the tester so that the skilled technician can concentrate his efforts on repairing malfunctions.

The equipment measures voltage,

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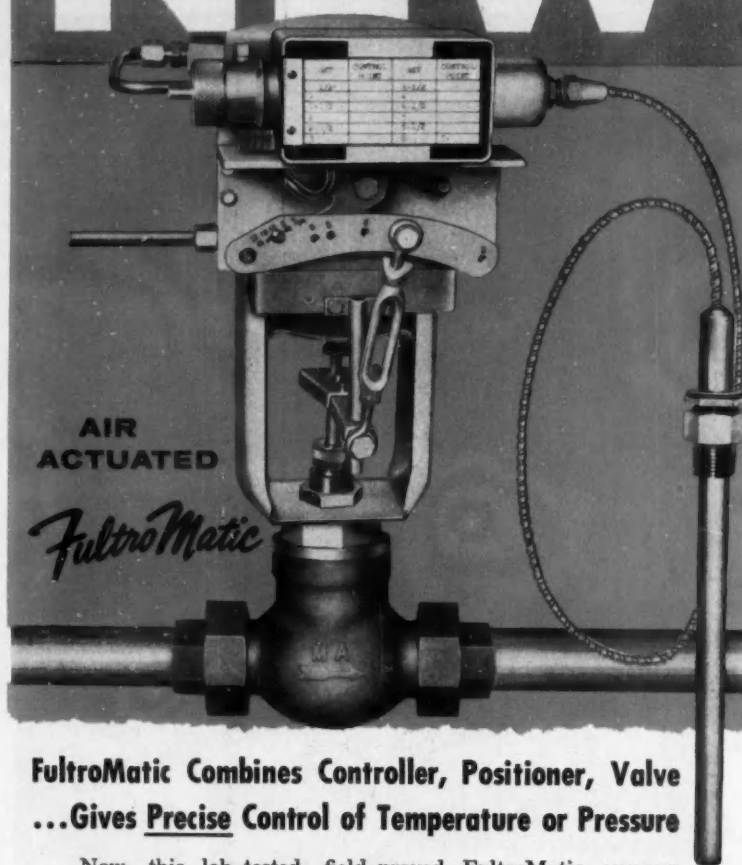
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COLLEGEVILLE, PENNSYLVANIA

CIRCLE 43 ON READER-SERVICE CARD

AUGUST 1959

43

# NEW 3-in-1 Controller at One-Half the Cost!



## FulthroMatic Combines Controller, Positioner, Valve ...Gives Precise Control of Temperature or Pressure

Now, this lab-tested, field-proved FulthroMatic answers today's precise control requirements with multiple features never before available in one unit . . . at about half the cost of two- and three-unit systems!

- **Improved accuracy** with smaller, faster-responding element.
- **Positive valve positioning** by feedback action; no overshoot.
- **Adjustable proportional band** easily changed on the job.
- **Simplified settings** with knob, indicator, arbitrary scale.
- **Field reversibility:** control action quickly changeable.
- **Easy to install:** place valve in position, mount bulb, connect air.
- **Low maintenance:** rugged design for trouble-free service.

FOR COMPLETE FULTROMATIC SPECIFICATIONS,  
WRITE FOR BULLETIN PW-755



## Robertshaw-Fulton

CONTROLS COMPANY

FULTON SYLPHON DIVISION • Knoxville 1, Tennessee

CIRCLE 44 ON READER-SERVICE CARD

## WHAT'S NEW

ac or dc; impedance; resistance; continuity; leakage; gain; or phase relationship. CTI expects the airlines will use it not only to check autopilots but also to inspect generating control systems, radar, and other electronic packages.

To do this, the airline needs a programmer adapter for each type of autopilot and electronic equipment. Cost of the adapters runs from \$110 for a 120 test unit to \$225 for a 400 test unit. But the big problem for users of the test equipment is the continuous stream of minor changes in avionic specifications made from year to year. Each change requires an adjustment in the adapter.

One possible answer to this problem is a punched tape program instead of the wired adapter. For minor changes the tape could be repaired or replaced. None of the airlines has purchased tape-programmed equipment yet. The main deterrent is price. A supertester with a punched tape block reader costs \$10,450—much more than the \$6,150 for a unit with a wired adapter.

With automatic equipment, the airlines expect to chalk up major time savings and better utilization of skilled electronic technicians. Next step: designing test plugs into the electronic equipment so that it can be checked in place on the airplane.

## Big Machines on Parade

*Numerical control makes possible a big automation program to make big products.*

SCHENECTADY—

Last month, executives of top U. S. machine-tool companies got a close look at each others' newest entries in the "special-machine" category. The occasion was an open house staged for the industry by G. E.'s Large Steam Turbine Dept., which is just winding up a massive modernization program. The latter was anything but routine in view of the nature of the product—huge, one-of-a-kind, and expensive turbines and generators.

Numerical control was clearly the star of the show: it was credited by G. E. people with making the difficult automation job not only feasible but economically justified as well. And these words came not from the naturally biased Waynesboro contingent of G. E. (who built the controls), but from Steam Turbine's manager of manufacturing, Bill Kuyper, who is

THOMAS A.

# EDISON

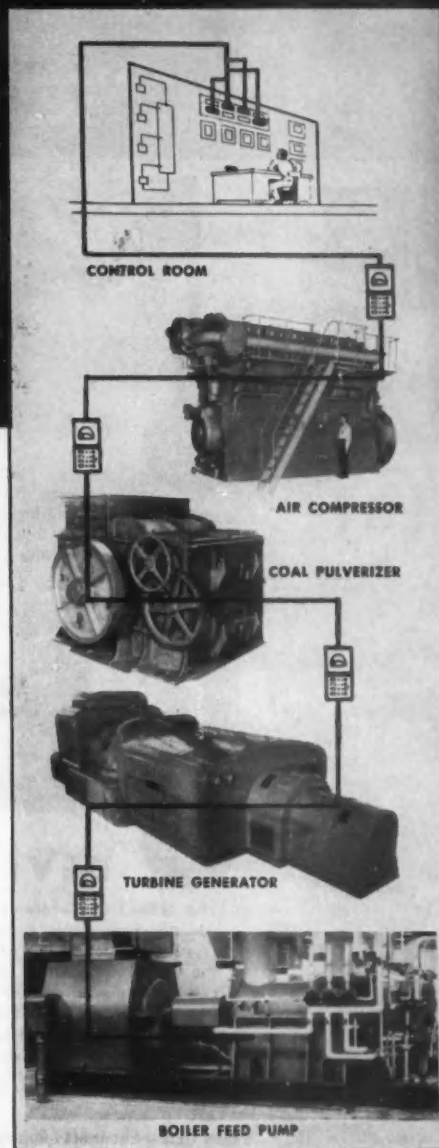
**omniguard systems  
protect equipment,  
decrease downtime  
in generating plants**

The Edison Omniguard system keeps constant watch on critical temperatures throughout electric generating plants. Omniguard monitors such vital temperatures as those of bearings on the main turbine generator, fluid drives, coal pulverizers, main feed pumps and other vital auxiliaries. When overheating occurs the alarm sounds *before* damage occurs and corrective action may be taken immediately.

By guarding against overheating the equipment runs at optimum efficiency, lasts longer and requires less maintenance.

This modern Edison system is a simple, reliable means of keeping equipment operating at full efficiency and protecting against emergency shutdown.

For additional information on Edison Model 310 Omniguard temperature monitor and the wide variety of detectors available for use on all types of auxiliaries, pressure vessels, tanks and pipe lines, write for publication 3036C.



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CIRCLE 45 ON READER-SERVICE CARD

the newest missile control  
systems and components at  
both 2423 WESCON Show.

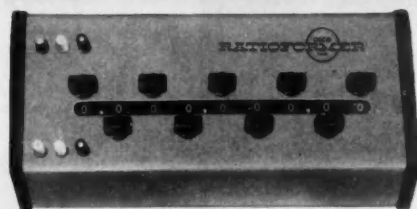
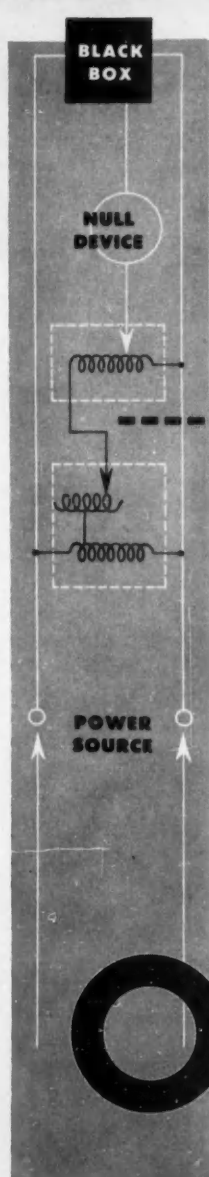
# LABORATORY ACCURACY for Production Line Testing...

Provides ratios of 3-to-1 step up to 10<sup>-6</sup> step down.

0.001% Ratio Accuracy at a 1000:1 step down; this is terminal linearity of 1 part in 10,000,000.

Easy-to-read, in-line numbers on sloping panel.

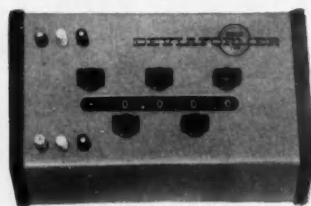
Adaptable to a wide range of test set-ups.



MODEL NO. 7600

## RATIOFORMER

Ruggedly built, the OECO Ratioformer provides over 300 million steps of precision ratio. The high input impedance, low output impedance, and extremely low phase shift make the OECO Ratioformer a versatile and adaptable instrument.



MODEL NO. 7500

## DEVIAFORMER

The OECO Deviaformer gives direct readout of percent of deviation from specified voltage ratios. Used with a precision AC voltage divider such as the OECO Ratioformer (or other ratio standard), it reduces the measurement to a % answer with extreme accuracy. Transformers, synchros, resolvers, computers, and meters can be tested on a simple "go/no-go" basis. Under rugged production line testing conditions, the accuracy level is maintained to 0.001%.

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See Our Demonstration at the Wescon Show—  
Booths No. 2122-2123

**CIRCLE 46 ON READER-SERVICE CARD**

## WHAT'S NEW

regarded as a tough prospect by machine-tool salesmen.

• **Card programmed slotter**—On display was a 100-ft long Simmons unit for machining slots in copper bars used in conductor-cooled generator rotors. Two decks of punched cards in two separate readers control the machine as it performs about 250 individual operations including, in addition to machining, the insertion and welding of plugs between the conductor bar ribs. Built almost two years ago, this machine was plagued by a series of "bugs" before it was put into daily use.

Another long-program machine on view was a Baker Brothers Inc. tape-controlled drilling machine having its turret carriage mounted on a horizontal slide 24 ft in length. This machine operates on turbine rotors requiring as many as 2700 ventilating holes.

Ex-Cell-O Corp.'s first attempt at numerical control, a machine for milling turbine buckets, was demonstrated. Ex-Cell-O will supply four such machines, all with two-axis magnetic-tape contouring control.

• **TV on the job**—The biggest of the machines featured in the open house was a Morton vertical boring machine. This machine operates on the inner surfaces of large turbine shells and incorporates a closed-circuit TV system to permit the operator to see the cutting tool.

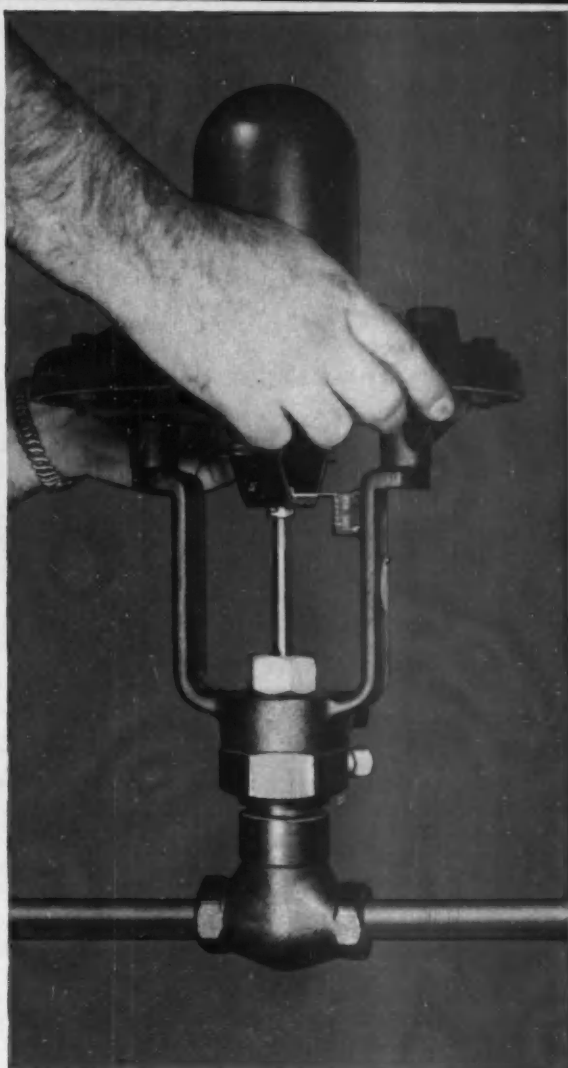
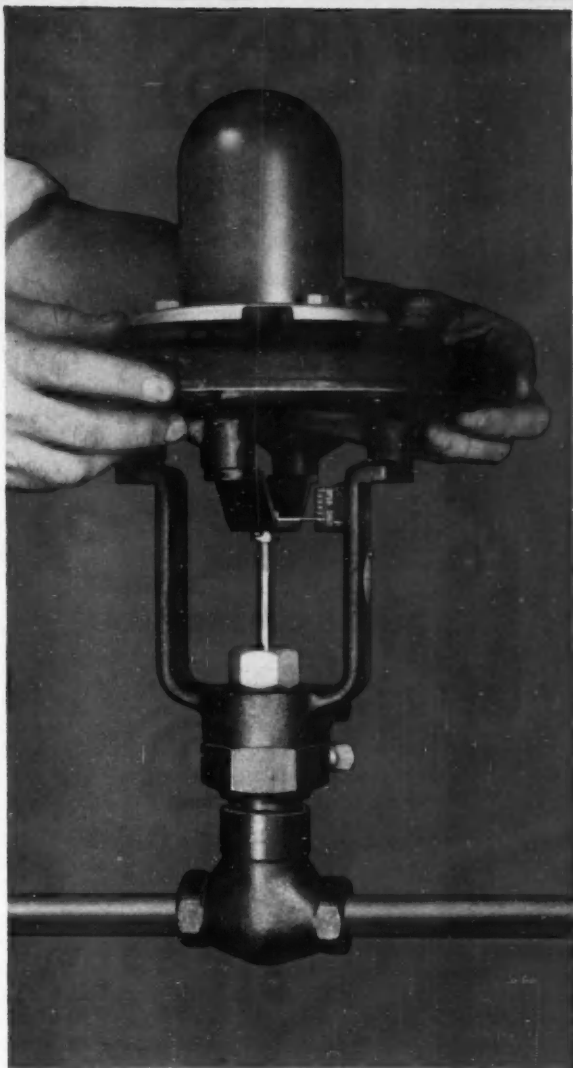
## Soviet Engineers Blasted By Russian Paper

MOSCOW—

The Soviet engineer who has been placed on a pedestal by the Russian government, showered with special rewards, and treated like a valued elite, may be in for a rude awakening. Last month the influential state newspaper *Izvestia* leveled a blast at research institutes, accused them of harboring ineffective engineers—"Babbitts in Science". Attacks in state newspapers are frequently forerunners of something much worse in the Soviet scheme of things.

*Izvestia* cited one of Russia's primary research institutes—Enims, the machine tool development organization—as a horrible example in the 2,000 word vitriolic blast.

It said educated goldbrickers, after earning university degrees, are "taking cover in the supposed complexity of the problems they are supposed to solve," producing nothing and at the same time blocking advancement of younger, more talented men.



## LOOK HOW EASY IT IS TO REVERSE THE ACTION OF A FOXBORO CONTROL VALVE!

air-to-open...air-to-close — one valve for the job of two

Unbolt the motor casing and rotate it 90°; rebolt and shift air connections — that's all you do to reverse the operation of a Foxboro control valve. Takes just a few minutes — without touching valve body or process piping — without employing special tools or skills.

Foxboro reversible motors are especially suited for needle valves, Saunders-type valves, and other control valves having non-reversible bodies. They're also used with Foxboro Stabilflo\*

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Foxboro control valves with their quick-reversible valve motor, are an exclusive Foxboro development. They're perfect for pilot plant operations and other processes frequently "juggled." Types and materials to meet any process requirement.

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CIRCLE 47 ON READER-SERVICE CARD

AUGUST 1959

47

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The complete line of Edcliff Instruments' Linear Motion Potentiometers is available end, side or bottom actuated with strokes up to 15 inches. They have high resolution, linearities to 0.05% and center or function taps. Engineered for reliable operation in high ambient temperatures, units are produced with one to four elements, depending upon the requirements of the particular application.

The full product line from Edcliff Instruments also includes Pressure Potentiometers, Angle of Attack Meters, Angular Accelerometers, Linear Accelerometers and Differential Transformer type Accelerometers.

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Write for Bulletin S11-WJ.



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CIRCLE 48 ON READER-SERVICE CARD

48 CONTROL ENGINEERING

## EUROPEAN REPORT



Japanese high speed printer with parametron circuitry was on display.

## C'est L'affaire de Parle

*International Conference on Information Processing started delegates arguing over new algebraic language and the proper approach to translation machines.*

PARIS—

In the diplomatic atmosphere of the spectacular new UNESCO house with built-in multilanguage translation facilities, the first International Conference on Information Processing opened like a plenipotentiary session of foreign ministers. And it wasn't too long before the scientists and engineers were sounding like politicians, too.

First a controversy boiled up over ALGOL, an international algebraic language for computer machines. It had been suggested that ALGOL be adopted as an international standard. Those for it pointed out that there would be tremendous advantages in using a single universal language. They described the good experience with it in Germany, the possibility of substitution of special characters, and its potential use for writing other systems directly by means of ALGOL language.

The opposition, on the other hand, laid down five good reasons against it. They warned that there was still limited experience with such a language; the new language would obsolete a large investment in existing programs; it would be expensive to convert to the new system; a large number of special type characters would be required; and there would be difficulty in learning a new system.

The present status of ALGOL after the oratory died down: the language agreed upon will be the 1959 standard and, subsequently, the language will be modified as experience dictates.

• **Translation battle**—Attendees were still discussing the pros and cons of ALGOL when another considerable difference of opinion developed. Two schools of thought appeared on machine translation of foreign languages. On one side were those who would concentrate study on the structure of language. A contingent strongly opposed) advocated using computers to analyze the foreign material to be translated.

There was no conclusion reached in this debate, and only time will tell which side was right—or most nearly right. For the present, the Russians appear to be moving from the latter to the former approach. American researchers seems to be moving in the opposite direction.

• **Auto-Math**—Across the street from the spirited technical sessions, computer manufacturers from all over the world were showing off their wares at a show called Auto-Math. Standard Elektrik Lorenz, Stuttgart, Germany, for example, displayed a fully transistorized machine, the ER-56. Price: \$200,000. It features parallel operation of all functional units.

A "traffic pilot" controls the infor-

# NEW... from Skinner!

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high-flow,  
solenoid valves  
for general  
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**Main orifice sizes:** full effective— $\frac{3}{8}$ ",  $\frac{1}{2}$ ",  $\frac{3}{4}$ " for  $\frac{3}{8}$ ",  $\frac{1}{2}$ ",  $\frac{3}{4}$ " NPT.

**Standard operating pressures:** 5 to 150 psi.

**Media:** oil, air, water, vegetable and petroleum oils, inert gases, kerosene, gasoline.

**Types:** normally open, normally closed and directional control in standard and explosion-proof construction.

These new, 3-way L3 Series valves, like all Skinner valves, are built to UL standards. Their bodies are made of forged naval brass and their internal parts are stainless steel and brass. Soft, synthetic inserts and seals provide bubbletight sealing. And a unique, Buna-N coated nylon diaphragm assembly assures long life. The valves are compact, light, and mount in any position, directly to the line. They are offered in a wide range of voltages and frequencies, with many electrical options and manual override.

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CIRCLE 49 ON READER-SERVICE CARD

AUGUST 1959

49

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Constructed to withstand severe vibration, heavy shock and  
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miniature size and dependable performance.



Nominal Coil Voltage: 26.5 Volts D.C.  
Maximum Pull-In Voltage: 18 Volts D.C.  
Maximum Drop-Out Voltage: 14 Volts D.C.  
Coil Resistance: Approximately 570 Ohms.  
Contact Arrangement: 2 P. D. T.  
Contact Rating: 2 Amps. @ 28 V. D. C. Resistive (max.).  
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Maximum Release Time (N.C. Contacts): 3 Milliseconds.  
Maximum Contact Bounce: 1 Millisecond.  
Dielectric Strength: 1000 V. RMS, 60 Cycles (Sea Level).  
Minimum Insulation Resistance: 100 Megohms.  
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CIRCLE 50 ON READER-SERVICE CARD

CONTROL ENGINEERING

## WHAT'S NEW

mation flow from six independent ferrite core memories to the arithmetic units, main stores, or input/output devices. Each memory is expandable in 200 or 1000-word increments to a maximum of 10,000 words. Instructions to the traffic pilot set up the connections and initiate the control logic in the functional unit.

• **Swedish Carousel**—An access time of 1.9 sec. for each information bloc on a five million decimal digit memory is the outstanding feature of Europe's first production carousel memory. Built by Facit of Sweden, the memory is part of the company's EDB computer system. Its main component is a 17-inch diameter alloy wheel containing 64 independent tape reels, each carry 28-ft. of tape. Storage is divided into 128 blocks of 64 words each; the tape has a capacity of 8,192 40-bit words. Because of the low access time and the large capacity, Facit says cost per decimal digit can be as low as 0.5 cents.

• **French symmags**—A French contribution to the show was the CAB 500, a transistorized, solid state, desk-size machine developed by Societe d'Electronique et d'Automatisme. An unusual feature of this machine: the 700 solid state logic units called symmags. Each one is composed of four ferrite cores, cross-connected via diodes to provide the complements, products, and additions of the control winding inputs when the cores are excited by a 200 kc supply.

Advantages claimed for the symmags are low cost—the CAB 500 cost about \$60,000, reliability, and immunity to supply frequency and amplitude variations up to plus or minus 35 percent.

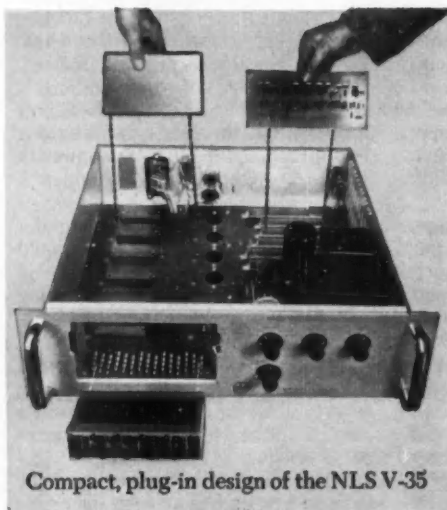
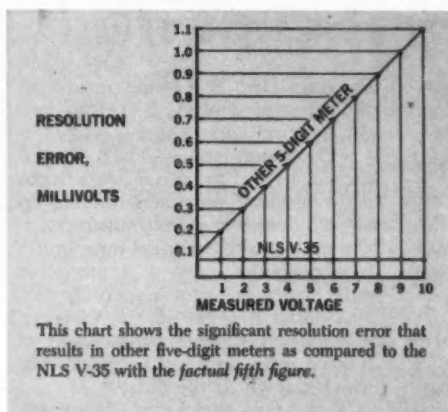
• **Parametrons from Japan**—Parametron applications were stressed in two Japanese designs. One was the Hipac 101 computer manufactured by the Hitachi Co. The other was a new printer that operates at a speed of 600 characters per sec—displayed by the Oki Electrical Industry Ltd. The printer uses an endless type belt actuated by 120 transistor-driven hammers, one for each line character.

Another Japanese firm, the Nippon Electronic Electric Company, displayed computers in which transistor circuitry replaced parametrons. The new machines, the NEAC 2201 and the NEAC 2203, succeed the NEAC 1103, a stored program, parallel operation computer.

—Ascher Opler  
Computer Usage Co.  
—Derek Barlow  
Control Engineering

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## The All-Transistorized NLS V-35

Here for the first time is a *true* five-digit voltmeter with a factual fifth figure. Increased accuracy of *full* five-digit resolution — 0.001% — results from the new mathematically perfect logic of the NLS V-35.

Other five-digit digital voltmeters require “desensitizing” to prevent oscillation of the least significant digit. This results in a resolution error of three to nine digits in the upper portions of each range as graphically displayed in the chart to the left. This comparison clearly shows the increased accuracy of the NLS V-35, made possible by full five-digit resolution.

In new logic . . . in all-transistorized circuitry, including logic . . . in new simplified design with *plug-in* circuit boards, *plug-in* oil-bathed stepping switches, and *snap-in* readout . . . the NLS V-35 leads its field. Write today for complete information.

### NLS V-35 Specifications

Measures Voltage from  $\pm 0.0001$  to  $\pm 999.99$ , Ratio from  $\pm .00001$  to  $\pm .99999$  . . . 10 Megohm Input Impedance . . . 0.01% Accuracy . . . Automatic Selection of Range and Polarity . . . And Measures Three Times Faster Than Any Other Stepping Switch Instrument.



Originators of the Digital Voltmeter

**non-linear systems, inc.**

DEL MAR (San Diego), California

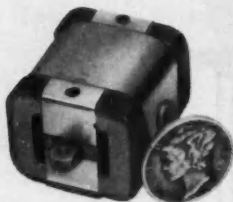
NLS — The Digital Voltmeter That Works . . . And Works . . . And Works!

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WEIGHT 2½ OUNCES  
patent applied for

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The design is simple and rugged. All motors must pass rigid acceptance tests, and a certified calibration curve is supplied with each motor. Atchley motors are offered in four sizes, with maximum force outputs from 1.5 to 13 pounds.

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CIRCLE 52 ON READER-SERVICE CARD

52 CONTROL ENGINEERING

## New Life at Panellit



AL SPERRY: A fortunate visit to a British associate.

A new subsidiary, and a new British computer have enlivened this midwest control maker. Here's how one company dropped its own research to take advantage of something better from abroad.

SKOKIE, ILL.—

After five hectic years and an expenditure of about \$2,450,000, Panellit, Inc., has plunged full tilt into computing-control through a newly-organized systems outlet.

Official debut will be made late this year when Panellit's fledgling subsidiary, Information Systems, Inc., delivers its first 609 information and computing system to Gulf States Power Co.'s Nelson Station at Lake Charles, La. Sometime next year, two more 609's will be delivered to the E. I. du Pont de Nemours & Co. chemical processing plant at Beaumont, Tex.

These are the only three firm orders Information Systems has received thus far, but Albert F. Sperry, Panellit president, and also head of ISI, isn't complaining. The company has issued orders for production of six more units not committed to any customers. Sperry hopes to sell \$2- to \$2½ million of the systems next year.

• **End a drain**—At the same time, creation of the new subsidiary will put an end to the financial drain on Panellit brought about by development costs of the 609. Sperry figures Panellit, which lost \$406,394 in 1958, will be firmly in the black this year.

It wasn't easy for Panellit to take the big step into computing control. The company was established in the graphic panel and annunciator fields through its Panellit and Panalarm divisions, and in data-logging through its

Panascan Div. But to get into more sophisticated control, it had to find the right computer.

• **Computer search**—Thus, beginning in 1954, Panascan division began research and development leading up to such a system. The company's engineers ultimately worked up a prototype computer using a Ramey core unit. Sperry quite frankly admits that a goodly share of the \$2,450,000 spent developing Information Systems to its present state went into this project, which was called the 608.

Then the unexpected happened. About two years ago, Sperry stopped in at Elliott Brothers, Ltd. of London, the British company with which Panellit already is affiliated through Panellit, Ltd. This organization, a wholly-owned subsidiary of Elliott Brothers, has the rights to everything Panellit builds in all Commonwealth countries except Canada, under a royalty agreement.

"I saw a prototype of a computer they were working on, which would do fifty things ours wouldn't do and was cheaper," says Sperry. Returning to this country, Sperry sent two computer specialists to see the Elliott unit, an all-solid state computer. When they came back with glowing reports, Panellit dropped work on its own computer. (One result: the director of research left.)

• **The Elliott 803**—Sperry then went back to England to arrange for exclu-

# Select the range for your requirements ... with these *ElectroniK* instruments

You get the advantages of *ElectroniK* accuracy and dependability in these special instruments . . . plus design ruggedness proved by around-the-clock service in industrial applications. They measure and record or indicate . . . quickly, precisely, conveniently. You'll find them particularly valuable in laboratory or test cell work where clear-cut evaluation and high resolution are needed.

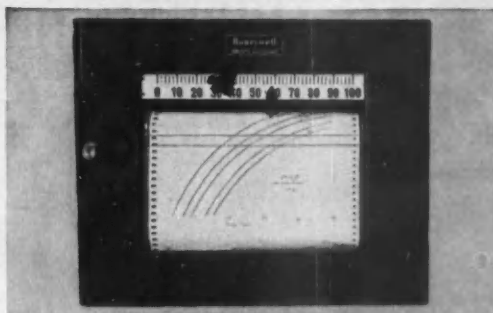
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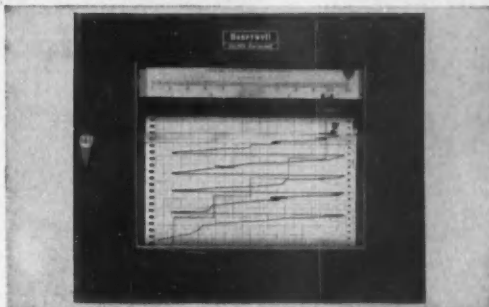
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**ElectroniK FUNCTION PLOTTER**—Automatically and continuously plots a curve which shows the relationship of one variable to another. Typical uses: speed versus torque, stress versus strain, plate voltage versus plate current, and many other variable relationships. Write for Instrumentation Data Sheet 10.0-5b.



**ElectroniK EXTENDED RANGE RECORDER**—Simplifies measurement of any linear variable whose values change over a wide range. Particularly suitable to the measurement of forces in conjunction with a strain gage bridge. Typical application: Projectile stress testing in wind tunnels. Write for Instrumentation Data Sheet 10.0-18.



**ElectroniK EXTENDED RANGE INDICATOR**—Incorporates extended scale and automatic range changing, serves in same applications as Extended Range Recorder. Resolution greater than one part in five thousand can be obtained, with use of a linear scale. As many as 10 ranges available. Write for Instrumentation Data Sheet 10.0-3.



**ElectroniK ADJUSTABLE SPAN RECORDER**—Measures spans and magnitudes of a variety of emf's. Instrument calibration can be in terms of any variable reducible to d-c voltage. Can be used with thermocouples, steam gages, tachometers, and other transducers. Write for Instrumentation Data Sheet 10.0-10a.

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CIRCLE 184 ON READER SERVICE CARD

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CIRCLE 54 ON READER-SERVICE CARD

CONTROL ENGINEERING

## WHAT'S NEW

**... the computer can change  
programs "in flight" ...**

sive rights to market the Elliott computer in the U.S. as part of the 609 system. The Elliott computer, then called the 802 and now called the 803, is being sold alone in England as a general-purpose machine. Some changes were made to make it fit in with the 609 system.

The Elliott computer incorporates 4,096 words of 40 bits each. But it can be expanded to 8,192 words, giving an ultimate capacity of more than 320,000 bits. Any number of outputs can be controlled in excess of 1,000 if required and such outputs can be added to the machine after it is installed in the field without any change in the basic machine itself.

• **The big feature**—The computer, says Sperry, is unusual in that it not only can compute simultaneously with scanning and processing, but also the programming can be changed "in flight", while the computer cycle is in progress. A b-line bit in every instruction word automatically modifies the program internally.

As of January, 1960, Panellit will make the Elliott computer available in this country as a scientific or general-purpose computer. This step is being taken as the result of a number of inquiries, according to Sperry.

Sperry doesn't claim the 609 systems sold thus far will be used for closed-loop control, although they have the capacity for this. Nevertheless, it is expected that the buyers will experiment with small closed loops.

The average 609 system with accessory inputs and outputs will sell for between \$150,000 and \$250,000.

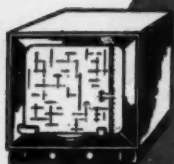
Sperry said Panellit is obtaining from Elliott a magnetic film storage unit with a capacity of 250,000 words and a high-speed card reader. They will be shown at the ISA show in Chicago this September. This marks a step in the direction of business machine use, even though they won't be marketed as such.

The agreement with the British firm did not provide for any exchange of stock between the two companies. Financing was another problem.

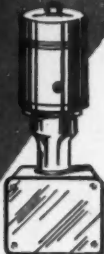
• **Changes in stock**—The venture into computing control wrought some noticeable changes at Panellit. Foremost of these was creation of Information Systems, Inc., as of March 10 of this year. ISI received the assets of the Panascan Div. in return for 140,000 shares of the new company's \$1 par value stock (plus \$2,601). ISI



CONTROLLER

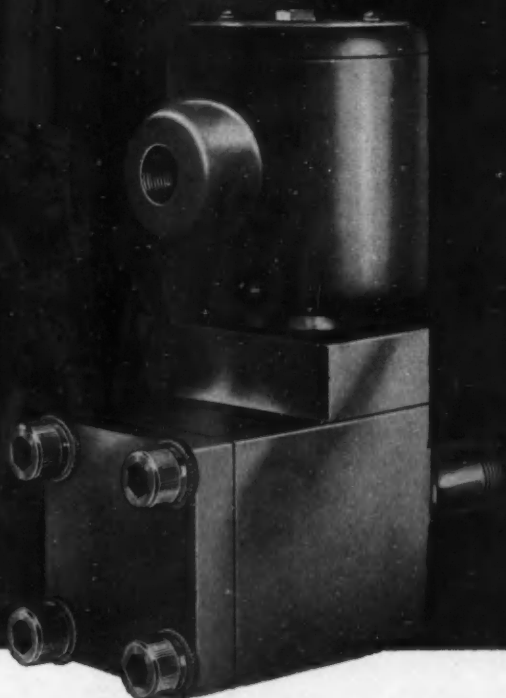


RECORDER



TRANSMITTER

# ASCO SOLENOID VALVES ARE ENGINEERED TO MISSILE GROUND SUPPORT REQUIREMENTS

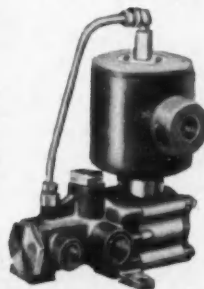


## Tight Shut-Off at Pressures to 3000 PSI, Temperatures to Minus 350°F.

ASCO now brings you a family of solenoid valves, specially designed for missile applications with tough environmental or operational requirements. Two, three and four way valves are available with standard, explosion-proof or watertight solenoids; sizes range from  $\frac{3}{8}$ " through  $2\frac{1}{2}$ ". Fluids handled include air, liquid oxygen, helium and nitrogen (liquid and gaseous). Valves can be supplied with continuous duty coil windings for 24 volts D-C, and for any other commercial voltages required. All types are packless (hermetically sealed), providing tight shut-off, with no external leakage to atmosphere.

**Two Way Valves** . . . normally open or normally closed, easily handle fluids at pressures to 3000 psi, temperatures to -350° F. Valves are stainless steel with teflon discs; most sizes are available with AN connections (Main Illustration-Bulletin 8223X).

**Three and Four Way Valves** . . . are suitable for piloting cylinder operated valves. Three way valves are also utilized for controlling single acting cylinders, and diaphragms; four way valves are used for controlling double acting cylinders. Unique poppet type seats and discs assure tight seating at pressures to 750 psi, temperatures to -65° F. Valve shown below (Bulletin 8344X) is suitable for 4 way applications, or may be used for 3 way installations by plugging one cylinder connection.



Proposals are submitted upon receipt of specifications—or an ASCO Engineer can help you in solving your ground support valving problems.

For additional information on ASCO Solenoid Valves for Missiles, write for Publication V5056.

### Automatic Switch Co.

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AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

# ASCO®

CIRCLE 55 ON READER-SERVICE CARD

Pressure Potentiometers for...

## HIGH TEMPERATURES and CORROSIVE FLUIDS



Type P103  
Pressure Potentiometer  
shown 3/4 size

New Trans-Sonics\* Pressure Potentiometers, Type P103, measure pressures of corrosive fluids such as red fuming nitric acid (RFNA) and unsymmetrical dimethylhydrazine (UDMH) for telemetry and control applications at ambient temperatures up to 600F.

Corrosive fluids are contained by a welded Inconel-X bellows which actuates a dynamically balanced mechanism. This mechanism is hermetically sealed in a stainless steel case for protection against corrosion and other environmental hazards.

Accurate and reliable performance has been proven under the following conditions typical of missile environments: *Random Gaussian Vibration* 0.1g<sup>2</sup>/cps, 15 to 2,000 cps; *Acceleration* 75g; *Shock* 75g.

Flexibility of installation is assured by small size and light weight. Dimensions are 1 1/8" diameter by 1 1/4" long. Weight is only 6 ounces. Standard ranges are 0-100 and 0-150 psia . . . other ranges to special order. Write for Technical Bulletin P103 to Trans-Sonics, Inc., Dept. 11, Burlington, Mass.

\*TRADEMARK

### TRANS-SONICS

*Precision Transducers*

CIRCLE 56 ON READER-SERVICE CARD

CONTROL ENGINEERING

### WHAT'S NEW

... new financing and a reshuffling of executives . . .

will be divided into a system group and a data-processing (computer) group. It will engineer assemble, and sell 609's, with all components—except the computer, which will be provided by Elliott—being provided by the parent company.

To finance its new subsidiary, Panellit has offered its shareholders rights to subscribe to about 170,000 shares of the company's new stock, at the rate of one share for each three common shares of Panellit held. Price is \$3.50 per share. On this basis, the company would take in \$595,000, if all rights were exercised by the deadline date in July.

Sperry expects most shareholders to exercise their rights. Panellit directors alone will bring in \$236,625 by exercising their rights.

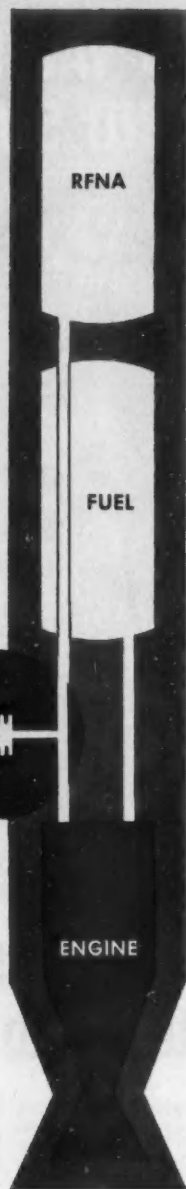
In order to furnish ISI with working capital before the stock offering, Sperry and his brother, Leonard M. Sperry, loaned the new company \$100,000, represented by unsecured 5 per cent notes, payable by Sept. 1.

Directors and executive officers of ISI are also directors and officers of Panellit. Albert Sperry, as president, is to devote not less than two-thirds of his time to the new company, under terms outlined in the stock prospectus. Sperry says it will be more likely 90 per cent.

• **Reorganization** — Warren Johnston, who formerly was head of the old Systems Div. at Panellit, heads up the new ISI organization and is the No. 1 man in sales and application. Two key men under him will be Gilbert Daniels, formerly director of research, who becomes chief of computer development; and O. A. Akerlund, formerly chief of engineering for Panascan, now in charge of ISI engineering.

In addition to Panascan and Systems moving into the new organization, there were other changes at Panellit. Panellit Service, which does contract work and maintenance, went through a management shakeup that resulted in the departure of Neil Blair, its chief, several months ago (he went to Intellects, an IT&T subsidiary). Panellit Service now reports to Marvin Lorig, who heads the Panellit Div., too. Lorig in turn has been relieved of all production responsibility. Howard Hudson, Panalarm head, will supervise production for all divisions.

Broadly speaking, under the new arrangement, ISI is responsible for



ISA SHOW  
BOOTH NO. 117

A unique combination of engineering and scientific skills, coupled with production ability... plus more than two decades of continuous development and production of newer and better airborne instruments — over 400,000 reliable guidance controls delivered — these are the reasons why Whittaker Gyro instruments are operational on many of the nation's major missile programs. From a simple gyro to complete stabilizing systems... Whittaker can provide the latest in design.



*Check These Advantages In The New Whittaker Sub-Miniature Rate Gyro!*

- reliable performance from — 65 F to 400 F
- only  $\frac{3}{4}$  inch diameter — 2 inches long
- non floated — eliminates fluid expansion problems
- quick start — no heater necessary

For additional information on the Sub-Miniature Gyro — on any specialized control components or systems... write today for technical data.

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TYPE FYLM

### 1 1/4" DIAMETER PERMANENT MAGNET MOTORS

- Three standard frame lengths
- Constant brush pressure over entire motor life
- Large, rugged bearings
- Very low ripple—14-bar commutator and 14-coil armature
- Standard or special mountings for interchangeability with other motors
- Radio noise filters, gearheads and other special features available

This popular sized motor can be supplied in voltages from 6V d-c to 115V d-c. Normal ambient temperature range -65° to 200°F (can be designed for -100°F or 400°F). Rated output, 10 mhp continuous to 35 mhp intermittent. Rated torque, .05 lb-in. to .16 lb-in. Weight, .26 lb to .43 lb. If you have a new or replacement motor application, contact Barber-Colman.

**THE WIDE LINE OF BARBER-COLMAN ELECTRICAL COMPONENTS** includes: D-C Motors for industrial equipment and aircraft control applications. Output up to 1/10 hp... permanent magnet and split series types... various mountings and speeds... also available with gearheads or blowers. Tach Generators for accurate speed indication and servo rate control applications. Low-cost battery-operated motors. Resonant Relays characterized by low operating power, narrow band width. Ultra-Sensitive Polarized Relays operating on input powers as low as 40 micro-watts. 400 Cycle A-C Motors for aircraft and missile applications.

**TECHNICAL BULLETIN SERVICE** on all Barber-Colman electrical components. Detailed specifications, performance data, circuitry drawings. Write for bulletins on any or all products.



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Aircraft Controls • Air Distribution Products • Overdoors and Operators  
Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

**CIRCLE 58 ON READER-SERVICE CARD**

58

**CONTROL ENGINEERING**

## WHAT'S NEW

systems, Panalarm for production, and Panellit and Service for contracting.

• **Cutting the pie**—Panalarm, the "bread and butter" division at Panellit, accounts for about one-third of the company's business, according to Sperry. The Panellit Div. accounts for approximately another third, while the Panascan and Services divisions account for about one-sixth each.

Sperry does not expect ISI to make a profit in its first year, although he is hopeful that it will in 1960. As for the parent company, he expects it to do "fair" business in 1959. Failure of the chemical and petroleum industries to resume building following the recession has hurt, Sperry admits. The power industry has helped take up the slack—it now accounts for almost two-thirds of Panellit's billings.

—Stewart Ramsey  
McGraw-Hill News

### TI Opens Flight Test Center

Texas Instruments, Inc., has set up an avionics flight test center at Addison Airport in North Dallas to test airborne electronic systems. First use of the new facility will be for in-flight tests of high resolution reconnaissance radars being built by TI for the U.S. Air Force and the Army Signal Corps.

### Epsco Launches New Subsidiary

Epsco Inc., data processing and telemetry manufacturer, has opened a subsidiary in Philadelphia. To be called Monitor Systems, Inc., the new organization will engineer and produce high speed electronic monitoring and automatic checkout systems. Harry M. Rosen has been appointed general manager of the new firm. He formerly was manager, data processing and computation in General Electric's missile & Space Vehicle Dept. in Philadelphia.

### WCEMA Becomes WEMA

West Coast Electronic Manufacturers Association has officially changed its name to Western Electronic Manufacturers Association. The change was prompted by the expansion of memberships into Arizona, Utah, Colorado, New Mexico, and Texas.

### Ford Merges Aeroneutronics

Aeroneutronic Systems, Inc., was merged with the Ford Motor Co., on July 1, 1959. More than 90 percent

of the outstanding stock of ASI was already owned by Ford at the time of the merger. ASI's operations will be carried on by Aeronautronic, a division of Ford. Gerald J. Lynch, formerly president of ASI, became general manager of the new division, was promoted to vice president.

Since it was founded in 1956, Aeronautronics Systems, Inc. has expanded rapidly, recently won a \$23 million contract to build the Army's Shillelagh surface-to-surface missile. It moved from 132nd place to 48th place among the top 500 Department of Defense contractors in net value of prime research and development contracts.

But plans for the new division are even more impressive. According to insiders, Ford has programmed the division to reach annual sales of \$125 million by 1965. It will hire 1,000 more engineers by 1963.

At the time of the merger, ASI was divided into four groups to concentrate on specific areas of technology: a computer group located at Santa Ana, Calif., a space technology group at Newport Beach, a missile range instrumentation group at Glendale, and a tactical weapon group just being formed. Later this year, all groups will be consolidated at a new facility in Newport Beach, Calif.

#### Other Acquisitions and Mergers

Hewlett-Packard Company will merge with Dymec Inc., will acquire Palo Alto Engineering Co. The merger with Dymec, whose stockholders are primarily employees of Hewlett Packard and Dymec, calls for an exchange of HP stock for Dymec shares. Similarly, the acquisition of Palo Alto Engineering involves a transfer of Hewlett-Packard stock. Dymec, founded in 1956, designs and manufactures instrumentation systems, has a current annual sales rate of over \$3 million. PAECO, started in 1951 by a group of Hewlett-Packard executives, manufactures a broad range of transformers, reached \$1.5 million in sales last year.

American Machine & Foundry Co. has merged its subsidiary Potter & Brumfield, Inc., into the company as a division. The relay manufacturer will operate as the Potter & Brumfield Div. of the company.

Systron Corp., electronic instrument maker, has purchased San Jose Scientific Co., whose strip chart recorders and digital voltmeters will be incorporated into the Systron line. All of San Jose's products will be marketed under the Systron name, will be made in Systron's Concord (Calif.) plant.

(Continued on page 144)

THE MARK OF QUALITY

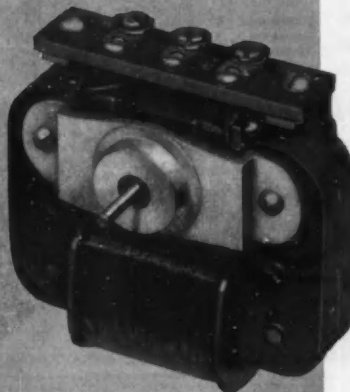


## a-c small motors

**low cost...rugged  
and accurate...**

### a-c tachometer generators

Here's a design tip that can save you money with no compromise in product quality! Barber-Colman reversible motors perform efficiently as dependable a-c tachometer or rate generators. Voltage is nearly linear in the range of 1000 to 3000 rpm and is usable beyond these speeds with but slight additional loss of linearity. Generated voltage is of the order of two volts per thousand rpm and can be increased to the order of 10 volts per thousand rpm with shading coils of higher impedance. Write for Bulletin F-9256 with performance curves.



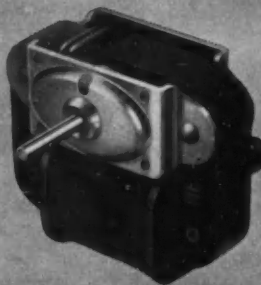
**low cost...reversible  
servo motors**

Compact, powerful . . . for servo-mechanisms, remote switching and positioning devices, recording instruments, voltage regulators. Adaptable to a variety of control circuits (including control from vacuum tube and transistor amplifiers) for power requirements up to 1/25 hp. Write for Catalog R1.



**low cost...unidirectional  
blower motors**

High-quality, precision-made motors that give long, trouble-free service for driving blowers and fans. Low noise level . . . long-life alignable bearings . . . large oil reservoirs . . . high starting torque. Ratings up to 1/20 hp. Write for Catalog U1.



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CIRCLE 59 ON READER-SERVICE CARD

AUGUST 1959

59

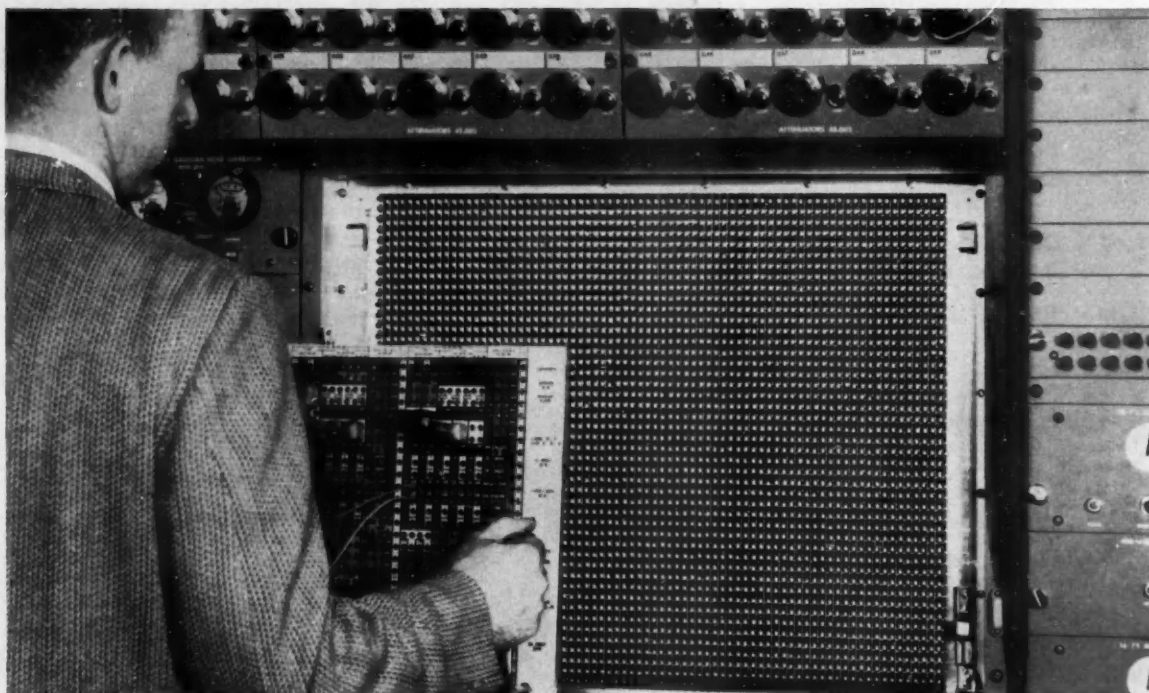
*You can see and feel  
the quality in EAI's*

# PACE

*analog computer*

There's a certain feel and appearance that goes hand-in-hand with quality and reliability. This is nowhere more evident than when you pull out the pre-patch panel in the PACE 231-R Computer. Feel the solid construction of the panel itself — notice the thousands of contacts in the patch bay, all plated with 24 carat gold. This reflects the quality built into every part of the PACE Computer.

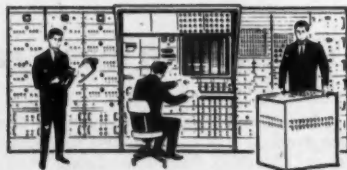
- Solid aluminum pre-patch panel is light and easy to handle. Its 3450 holes are precision drilled to .001 of an inch. It will not warp, bend or crack.
- The rack and console are of welded, heavy gage steel construction for added protection to precision components.
- 3450 contacts in the patch bay are plated with 24 carat gold. This provides unusually good electrical contact... important for accuracy at low voltages and currents.
- Contacts are isolated from each other by cells to shield against pick-up and cross talk.



Contacts in patch bay are plated with 24 carat gold for maximum accuracy at low voltages and currents.

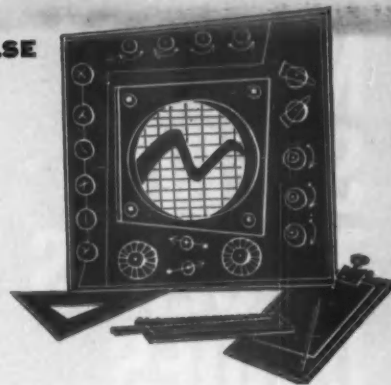
- Coaxial leads and individually shielded amplifiers are part of a complete shielding system that extends throughout the computer.
- Bus bar power distribution provides an added measure of reliability and simplifies inspection and maintenance.
- Over 100 inspectors are engaged full-time in checking quality and performance of parts, circuits and systems.
- Components and sub-assemblies must pass seven separate tests—one test requiring 4 to 6 weeks to complete.

**Outstanding career opportunities for engineers with proven ability—résumés invited.**



# EAI

ELECTRONIC ASSOCIATES, INCORPORATED  
Long Branch, New Jersey



## Instrument Export Booms: But for How Long?

Export of U.S. instrumentation and control devices is well ahead of last year, one of the few categories of U.S. goods in that position. Export of most other goods is slipping, a continuation of a trend which started last year. In 1958, while exports of U.S. precision instruments increased almost 10 percent to \$231 million, U.S. total exports slumped \$3 billion from the 1957 record high of \$19 billion. The big question is how long will instrumentation and control continue on the increasing side. Will they too succumb to what ails other U.S. products?

Here are some typical reports of how exports of instrumentation and control devices have fared in the first four months of 1959:

- Industrial indicating and recording instruments and parts: \$15.5 million, just above the amount exported for four months in 1958 (12-month exports in 1958 totaled \$16 million).
- Indicating, measuring, recording, and controlling instruments and parts: \$6.3 million (12-month exports in 1958 were \$16 million).
- Electronic computers and related information processing machines and accessories: \$6.5 million (far ahead of last year's rate in which 12-month exports were only \$15 million).
- Physical properties testing and inspecting machines and parts: \$4.2 million (12-month exports in 1958 were \$13 million).
- Electronic industrial process control systems: \$243,000 (over half of the 12-months exports in 1958, \$432,000).

Compare these healthy gains with what has been happening to other types of products. In 1958, these skids were recorded:

- Automobile exports fell by \$57 million, down 19 percent from the 1957 total of over \$300 million. For the first four months of 1959, auto exports (new and used) were \$93 million—slightly above last year's rate but still well below 1957.
- Exports of construction machinery dropped \$200 million below the total of 1957.
- Exports of petroleum products, which had soared to record levels in 1957 because of the Suez crisis, dropped from almost \$1 billion in 1957 to \$560 million last year. For the first four months of this year, exports totaled \$161 million, portending another sizeable drop in 1959.
- Tractor sales dropped \$50 million in '58, a serious blow to tractor makers who have sold as much as half their output abroad.
- Sales of U. S. trucks and buses in export markets were hit worse than auto sales: they were off 32 percent, \$140 million. Exports for the first four months of 1959 were only \$113 million, indicating another slide is underway.

Strangely, the reason most often given for the slump is the same one offered to explain the increase in exports of instrumentation and control devices. That is the economic resurgence of Western Europe, and world trade in general. European countries, particularly, have been

### Instrument rise

### Other products fall

### The reason why

# NOW — SPECIFY TI GLASS DIODES MEETING AIR FORCE SPECS!



## Guarantee 400 ma DC at 1 v

TI AF1N645, AF1N647, AF1N648 and AF1N649 diffused-silicon glass diodes now meet MIL-E-1/1143... giving you 400 ma DC at 1 v... 225 to 600 v PIV... operation from  $-65$  to  $150^{\circ}\text{C}$  and 600 mw dissipation. The inherently low junction temperature of these TI glass diodes provides a new high in reliability by combining the lowest forward-voltage drop with high power dissipation package.

In commercial production for more than two years, the 1N645 series is available in *production quantities* to meet *all* your requirements.

Simplify your procurement and stocking problems by standardizing on the TI 1N645 series... truly general-purpose high-reliability diodes. Contact your nearest TI Sales Office for fast delivery of production quantities.

### maximum ratings

	AF1N645	AF1N647	AF1N648	AF1N649	
PIV	225	400	225	600	v
$I_F$ @ $25^{\circ}\text{C}$	400	400	400	400	ma
$I_F$ @ $150^{\circ}\text{C}$	150	150	150	150	ma
$P$	600	600	600	600	mw
$T_J$		$-65$ to $+150$			$^{\circ}\text{C}$

### specifications

	AF1N645	AF1N647	AF1N648	AF1N649	
$V_F$	0.7	0.7	0.7	0.7	v
$I_F$ @ $25^{\circ}\text{C}$ & PIV	0.2	0.2	0.2	0.2	ma
$I_F$ @ $100^{\circ}\text{C}$ & PIV	0.2	0.2	0.2	0.2	ma
Capacitance @ 400 ma dc	1.0	1.0	1.0	1.0	pF
$C_{trr}$	9	9	9	9	ns



FROM THE WORLD'S LARGEST SEMICONDUCTOR PLANT



**TEXAS INSTRUMENTS**  
INCORPORATED  
SEMICONDUCTOR-COMPONENTS DIVISION  
POST OFFICE BOX 312 • 13500 N. CENTRAL EXPRESSWAY  
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## Cost advantages abroad

## Two key factors

# NEW FROM PHILCO

## HIGH FREQUENCY NPN SILICON DIFFUSED-BASE TRANSISTORS\*

**30mc  
PULSE RATE  
SWITCHES**

Type Number	$h_{fe}$	Typical Power Gain	Typical Switching Times (Saturated Test Circuits)
2N1199	12-60 (DC)		$t_r$ 35 $\mu$ sec $t_d$ 10 $\mu$ sec $t_f$ 25 $\mu$ sec
2N1267	6-18	} 25 db at 4.3 mc	
2N1268	11-36		
2N1269	28-90		
2N1270	6-18	} 25 db at 12.5 mc	
2N1271	11-36		
2N1272	28-90		
Maximum $V_{cb}$ —20 V Maximum temperature—150° C Maximum dissipation—100 MW			

**60mc  
AMPLIFIERS**

### 2N1199

This high speed switch has exceptionally low saturation voltage (typically 0.125 V), permitting *practical* design of 3 mc pulse circuits, using conventional saturated switching configurations. 30 mc pulse rates are obtainable in *practical* circuits using non-saturating techniques.

### 2N1267-68-69

The high gain characteristics of these units make possible the design of high efficiency IF amplifier circuits for communications equipment. These devices have unusually low collector capacitance . . . typically 1.5  $\mu$ f . . . and are available with restricted beta ranges to simplify design problems.

### 2N1270-71-72

The excellent high frequency response of these transistors makes practical the design of high performance communications systems at frequencies up to 60 mc. They have the same low collector capacitance and are available with restricted beta ranges.

*Immediately available for prototype design from your Philco Industrial Semiconductor Distributor.*

*Write Dept. CE-859, Lansdale Tube Company, Division of Philco Corporation, Lansdale, Pa.*

*\*SADT . . . Trademark Philco Corp. for Surface Alloy Diffused-base Transistor.*

# PHILCO

**LANSDALE TUBE COMPANY DIVISION**  
LANSDALE, PENNSYLVANIA



GUEST EDITORIAL

The assembly in Chicago next month of International Federation of Automatic Control delegates (IFAC) will emphasize the fact that control engineering recognizes no international boundaries. As the event approaches, American engineers may well be interested in the gains for the U. S. in continued active participation in IFAC. We have asked Harold Chestnut, first president of IFAC, and control systems engineer, General Engineering Lab., General Electric Co., to explain the possible benefits. Ed.



## IFAC is a Two-Way Street

IFAC provides an opportunity for information to flow to, as well as from, America. U.S. control knowledge and control equipment have had a broad acceptance throughout the world and it is important that this influence continue to be felt. Other countries are well aware of what is taking place technically in the U.S. IFAC will help Americans interested in control to learn of the new ideas and new developments being generated elsewhere in the world before they have become accomplished facts.

Control ideas and know-how, basic ingredients for increased production, can be readily transmitted through IFAC technical committees and international congresses such as that to be held in Moscow in 1960. To the extent that the U.S. recognizes its opportunity to be of service to less developed countries of the world, it can influence them to adopt standards and equipment similar to those employed in America. Although the immediate gain appears to be with the countries learning of the U.S. technical advances, the good will and technical acceptance of U.S. methods in the long run may represent the more valuable benefit to American control people.

Discussions of these points will not arise in the IFAC assembly in Chicago, for it will be a busi-

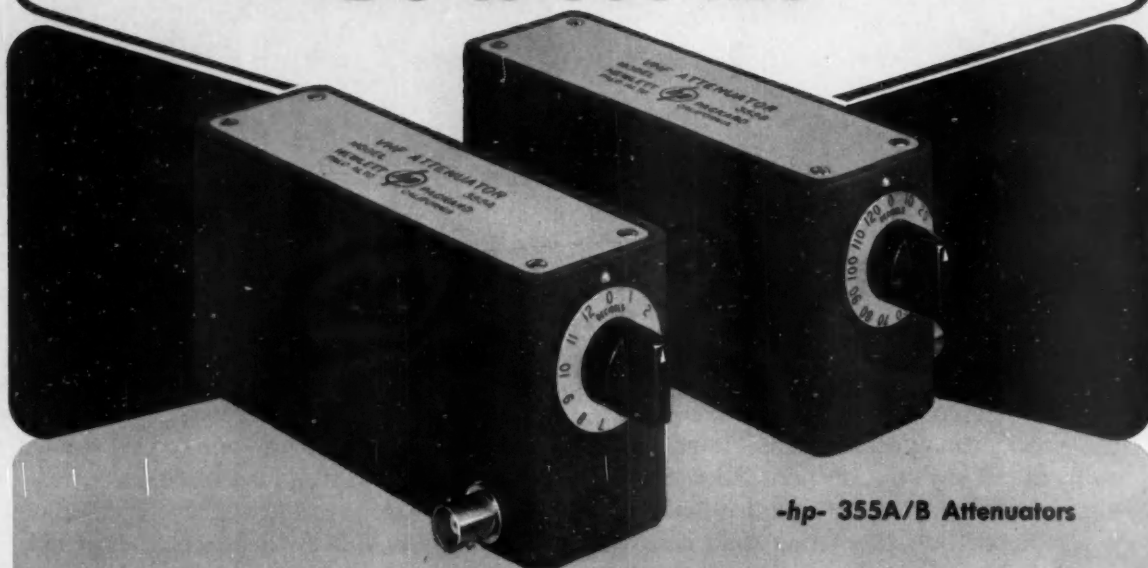
ness meeting to elect officers and to hear reports of the progress that IFAC has made since it was founded two years ago in Paris. Presentation of technical papers by IFAC representatives at ISA sessions following the assembly should demonstrate, by example, the immediate gains we can expect. Eight speakers from Japan, Germany, Sweden, U.S.S.R., England, Czechoslovakia, and France will report on facets of instrumentation and control that the special nature of industrial problems in their countries have required them to study.

No one country has a monopoly on technology. Because of different interests and backgrounds we see such islands cropping up: organic models of learning machines in Great Britain, pneumatic logic systems in Russia, unusual numerical control applications in Japan. And even though a country may have only one or two control specialists, it is still possible for the few to pursue effectively a unique corner of the technology.

So IFAC is a two-way street. U.S. control engineers will give, but they will also receive technical information and ideas. And for those concerned with marketing, such an interchange of ideas can lead to increased trade, new products, and even new industries.

*Harold Chestnut*

**New design 50 ohm attenuator**  
**0 to 132 db in 1 db steps—**  
**DC to 500 MC**



**-hp- 355A/B Attenuators**

¼ db accuracy full range for low attenuation values. Maximum error at full attenuation 2 db. "One-knob" control. Super compact design—size approximately 2½" x 2½" x 6".

These are characteristics of the new, rugged, simple -hp- 355A/B attenuators.

-hp- 355A provides 0 to 12 db in 1 db steps. -hp- 355B provides 0 to 120 db in decade steps. Together, 132 db of attenuation from DC to 500 MC is available, with simplest possible controls, pre-

mium accuracy, and no complex setup. A solid-shield 50 ohm connector may be used to interconnect the two attenuators.

These new -hp- attenuators have balanced capacities and completely shielded sections. They are enclosed in a sturdy metal case, yet weigh only 1½ pounds.

Ask your -hp- representative to show you these practical, minimum-space attenuators this week.

**SPECIFICATIONS**

**Attenuation:** -hp- 355A, 12 db in 1 db steps. -hp- 355B, 120 db in 10 db steps

**Frequency Range:** DC to 500 MC

**Overall Accuracy:** -hp- 355A, ±0.25 db, DC to 500 MC. -hp- 355B, ±1 db, DC to 250 MC, ±2 db, 250 to 500 MC

**Nominal Impedance:** 50 ohms

**Maximum SWR:** 1.2 to 250 MC, 1.5 to 500 MC

**Max. Insertion Loss:** 0 at DC, 0.4 db at 60 MC, 1 db at 250 MC, 1.5 db at 500 MC

**Power Dissipation:** 0.5 watt average; 350 v peak

**Connectors:** BNC

**Size:** 2-3/16" wide, 2-5/8" high, 6" long. Net weight 1½ pounds

**Price:** -hp- 355A, \$125.00. -hp- 355B, \$125.00

*Data subject to change without notice. Prices f.o.b. factory*

**HEWLETT-PACKARD COMPANY**

4643H PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U.S.A.  
 CABLE "HEWPACK" • DAVENPORT 5-4451  
 FIELD ENGINEERS IN ALL PRINCIPAL AREAS

**hp** offers over 350 quality electronic test instruments

# INSTRUMENT SPECIFICATIONS

## *communication link between user and maker—*

To find out how instrument users can take advantage of good specifications, **CONTROL ENGINEERING** studied the procedures of six chemical, petroleum, and contractor firms. Procedures vary, as shown by the summary (next page) of how these organizations specify and buy instruments. Even so, the study brought to light three common and important points: specifications are a written link between user and maker; they depend on a flow of information about the process to the instrument engineer; and they vary in detail depending on instrument uniqueness.

The benefits of well-prepared instrument specs are:

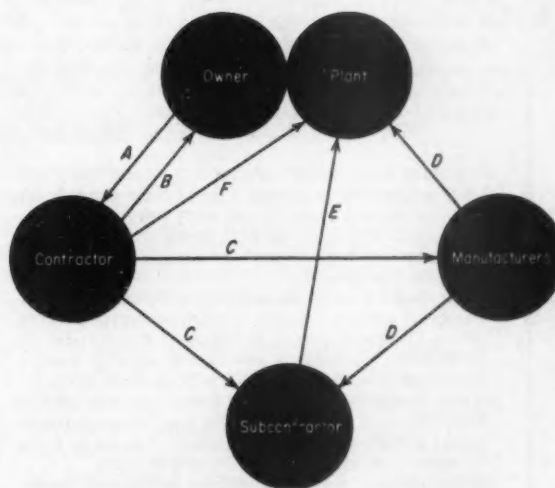
- ▶ to assure the maker produces what the user wants
- ▶ to assure the plant owner's intent—to own a plant producing at a certain rate by a certain date—is met
- ▶ to minimize instrument engineering and installation costs
- ▶ to give makers and contractors the opportunity to employ their experience and ingenuity on behalf of the owner
- ▶ to reduce contingency factors in quotations by makers and contractors

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Instrument specifications incorporate characteristics determined after extensive study of instrument location and intended function, after review of process demands, and after coordinating these specs with specialists in the Process, Piping, and Mechanical Departments. Specifications communicate these characteristics to instrument manufacturers. When an engineering contractor acts on the owner's behalf, instrument purchasing specifications communicate between three parties—owner, contractor, and manufacturer; and should a subcontractor, such as a maker of graphic panels, enter the picture, the specs tie in a fourth party as well. Specifications are used by owner's inspection personnel at the maker's plant and by installation and startup crews at the construction site. Figure 1 shows the various groups affected by instrument purchasing specs during design, construction, and startup to assure a successful process.

### Three patterns for specifications

Even though specification practices vary from company to company and project to project, they reveal three common patterns. First, instrument specifications are vehicles that spell out performance, construction, and function; reflect engineering exper-



**FIG. 1 INSTRUMENT SPECIFICATIONS AID COMMUNICATION**

- A Owner's process and plant specifications.
- B Contractor's instrument purchasing specs for review.
- C Instrument and systems specs and purchase orders.
- D Instruments delivered to subcontractor and plant.
- E Systems delivered to plant site.
- F Instrument specs to plant for installation and startup crews.

ience; and spur makers to improve their products. The information actually contained in any particular specification depends on technical and organizational factors, and how the owner chooses to purchase instruments.

Second, instrument specifications exist in a hierarchy of specifications and standards developed by other engineering groups.

Third, instrument specs differ in detail, depending on instrument uniqueness, and result in a horizontal pattern. For example, an engineer can buy a conventional controller (Class I, Figure 2) by listing maker and model number on a purchase requisition (without any formal specification), and he can be fairly certain—because so many instruments of this kind are already in use—that the instrument will function properly when installed. This procedure will not suffice for a stream analyzer (Class II), of course, because it would leave unanswered for the vendor such details as the minimum and maximum ranges of stream components, and the component for which the analyzer should be sensitized. These conditions—and many more—must be specified. Still more detail—perhaps eight or 10 pages of requirements—is needed for such complex systems as data loggers and graphic panels (Class III), for their design requires coordination of instruments from several sources and mutual agreement on philosophy of plant operation.

In purchasing instruments, both the vertical and horizontal aspects of specification preparation, Figure 2, come into prominence, to determine what information should be conveyed to the vendor and how detailed this information should be. Consider first the vertical flow of information.

## The hierarchy of specifications

Procuring an instrument always involves preparing a purchase requisition. If the instrument needs must be explained in some detail, the engineer may prepare, in addition, an instrument work sheet and even a purchasing specification for that instrument. Here's how instrument specifications originate.

**Engineering standards** detail company practices. They guide the instrument engineer in the design, selection, and installation of control devices and systems, and in written form are useful for training new engineers, for clarifying conflicts, and for carrying out construction projects by contracting organizations in accordance with the owner's requirements. Written or unwritten, engineering standards always exist, by virtue of an instrument engineer's job knowledge and experience.

Engineering standards are not instrument specifications; they simply tell the instrument engineer the circumstances, including process conditions, under which a typical piece of equipment, such as a particular control valve, should be used. A control-valve engineering standard would include information about how to size valves, what packing to use, when to use flange or thread connections, when to use valve positioners, when to use linear or equal-percentage characteristics, etc.

**Example: 1. Equal-percentage plug characteristics shall be specified when a) pressure drop across valve varies appreciably, or b) wide rangeability is required. 2. A valve positioner shall be used when the valve is located more than 200 ft from the controller.**

Process specifications detail information about

### HOW SIX ORGANIZATIONS PREPARE AND USE INSTRUMENT SPECIFICATIONS

It would certainly seem reasonable to expect each instrument-user company to develop a specification procedure—an organized approach to writing and using instrument specifications—and to find similar practices among various companies. This is not the case, however. Specifications practices vary widely. For example:

► One large petroleum company tells instrument manufacturers what it wants by preparing comprehensive general specifications for valves, rotameters, controllers, transmitters, etc. For a specific application, a work sheet is prepared, based on information in the general spec, in process specifications, and in engineering standards. The work sheet thus exactly specifies those instrument features needed for a particular application. Several qualified makers are then asked to bid, and in theory the maker submitting the lowest bid gets the order.

► One chemical company establishes performance requirements, by evaluating various instruments and setting up a list of approved vendors for those instruments that meet the requirements. Specifications are not sent to the vendor. Once an instrument, for instance a differential-pressure transmitter, is assigned to the process flow sheet, only those vendors on the approved list for that device get the opportunity to bid. Selection is simple and straightforward: performance, not price, is paramount—and performance can be assured simply by buying an approved make and model number.

► At a midwestern chemical company, the evaluation engineers' mission is to determine how well available instruments meet the maker's—not the user's—specifications. Within this multiplant company, such findings are advisory rather than mandatory in guiding instrument buying; though eventually the information will be used in preparing company-wide specs and in tightening up on instrument performance as may be determined by system analysis.

► Another oil company depends on a contractor to buy instruments to contractor's instrument specs. This owner prepared rather broad specs outlining overall plant requirements, wants low cost with performance guaranteed by the contractor.

► A third petroleum company, recognizing that over the years conflicting instrument requirements, redundancies, and extraneous details may have increased the cost of plant construction, has its specs analyzed and streamlined by an independent engineering firm.

Contractors prepare instrument specifications for owner-clients. Like specs developed by owners, contractors' specs incorporate the performance and design characteristics of the best available instruments. Such specs have been used successfully on a wide range of installations and processes. Often, an owner adopts a contractor's instrument specs—perhaps with some modifications—as a good start on expanding his own procedures.

FIG. 2 HOW INFORMATION FLOWS TO INSTRUMENT SPECIFICATIONS

process equipment and piping, what variables must be controlled to operate the plant successfully, etc. Of particular importance here are such matters as maximum and minimum flows, corrosive and erosive materials, pressure drops and ranges, viscosity and specific gravity of fluids, hazardous conditions—all of which influence selection and installation of instruments and controls.

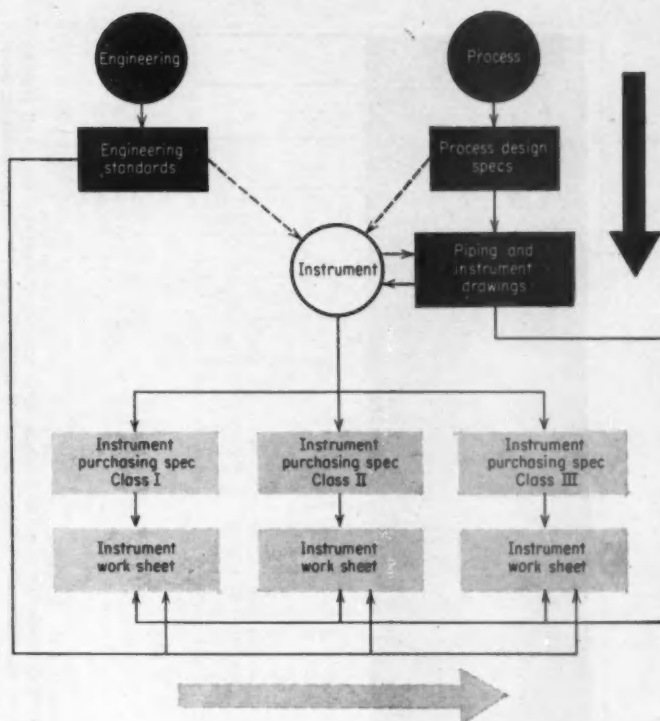
The Process group also initiates a piping and instrument drawing (PID) showing the location of equipment and piping and suggesting location and function of the necessary instruments. Working closely with the process people, the Instrument group verifies the appropriateness of the instruments and suggests changes that may better meet process control requirements.

**Example:** Salt water is used to cool a vessel; nominal flow is 100 gpm, but varies from 10 to 150 gpm; flow is automatically adjusted by a control valve operated by a controller sensing temperature.

Piping and instrument drawings portray the process equipment and the instrumentation needed for its control. The PID, a typical one is Figure 3, page 72, can be used in discussions with vendors, to get a rough estimate of instrument costs. With the piping and instrument drawing, the engineering standards, and the process specifications, the instrument engineer can select and procure instruments having the appropriate function, performance, and construction. Each device is analyzed in the light of its own operational situation, and is specified accordingly. Final selection is made with the aid of a general (purchasing) spec for that device, with more specific features detailed on a work sheet.

**Example:** The PID shows a vessel, a pump for the (salt) cooling water, piping, and location of temperature-sensing element, controller, and control valve. The distance between controller and valve is 275 ft and demands a valve positioner; the instrument engineer modified the PID to show this.

Instrument purchasing specifications, a separate one for each instrument, cover general and unique requirements for that instrument and its common variations. For a rotameter, the specification would describe the general requirements for rotameters as a class and special requirements for enclosed, gage-glass, and armored rotameters. General requirements in a purchasing spec include materials of construction, mechanical connections, definition of terms (often in pictorial or graphical form), design and construction of individual parts, procedure for handling conflicting requirements, reference to associated (company, ISA, ASME, and ASA) standards



and specifications, and statements about accuracy, repeatability, dead zone, linearity, etc.

**Examples:** 1. For equal-percentage flow characteristics, the valve's plug (or port opening) shall be shaped so that with constant pressure drop across the valve, the percent change in flow per unit change in stem lift is constant. 2. The valve positioner shall be supplied only when specified on the work sheet for the associated valve.

Instrument work sheets are checklists of important items needed to specify instruments, with blank spaces for entering process information (such as nominal, maximum, and minimum flow), and decisions made from this information (such as valve size and trim material). Thus, a work sheet is more specific than its associate purchasing spec, and it conveys to the maker the pertinent requirements for a particular device for a specific application.

Work sheets permit an orderly breakdown of total instrument needs, shown on the PID, into individual devices. Most frequently, a work sheet lists specifics for all like devices (control valves) for a process, though some companies prefer a work sheet detailing all instruments in a particular control loop—often going as far as to draw a simple PID for that loop on the sheet. Many companies use work sheets alone, do not prepare purchasing specs; they let the maker's specification act in the same capacity as the user's purchasing spec. The Instrument Society of

Instrument number	Sample stream	Service and logging	Type of analyzer	Sample line			Composition to be analyzed	Condensible vapors and quantities present	Pollutants (dust, dirt, soot, fumes, etc.)	Analyzer calibrated for (element or compound)	Range of calibration	Accuracy	Location	Average ambient temperature range	Housing		Distance between analyzer and recorder	Recorder		Mfr	Mr's model catalog figure, or series number		
				Temperature	Pressure	Length									Type	Mounting		Chart	Range			Mounting	
AR 201	METHANE ANALYZER	INFRARED	→	775 (1470°F) AT SAMPLE POINT	8.5 (120 PSIG)	10 METERS	H <sub>2</sub> MAX 55.0 MIN 35.0 N <sub>2</sub> 4.0 2.0 CO 12.0 4.0 CO <sub>2</sub> 4.0 10.0 A TRACE CH <sub>4</sub> 6.0 2.0 H <sub>2</sub> O 18.0 47.0 100.0 100.0	H <sub>2</sub> O VAPOR AS SHOWN IN COMPOSITION	PIPE SCALE	CH <sub>4</sub>	0-10% FULL SCALE	±1% SCALE RANGE	OUTDOORS	MIN WINTER -10°C MAX SUMMER +35°C	WEATHERPROOF	MFR STD	70 METERS	ONE	CIRCULAR	Range	Mounting	Analyzer	Recorder
	REFORMED GAS			H <sub>2</sub> MAX 35.0 MIN 20.0 N <sub>2</sub> 15.0 8.0 CO 10.0 4.0 CO <sub>2</sub> 2.0 A 0.02 CH <sub>4</sub> H <sub>2</sub> O																			
2	QUENCH DRUM EFFLUENT			340 (650°F) AT SAMPLE POINT	8.5 (120 PSIG)																		
3	SYNTHESIS GAS TO REACTOR			21 (70°F) AT SAMPLE POINT	17.6 (120 PSIG)																		

NOTES:

- One instrument is to be furnished to analyze each sample stream. Vendor shall provide a field-mounted analyzer with solenoid actuated valves in sample-select manifold. Solenoid valves are to be manually operated from recorder in control room.
- Average barometric pressure 760 mm.
- Vendor shall furnish all accessory equipment to condition and regulate the sample except for pipe and pipe fittings. Vendor shall submit with quotation a drawing of complete sampling system showing all pertinent equipment, pipe sizes, and connection sizes. Vendor shall also submit with quotation a wiring diagram of the complete system with recommended

Courtesy: M. W. Kellogg Co.

**TABLE I**  
**PURCHASING SPECIFICATION—**  
**GAS ANALYZER**

**NOTES:**

- One instrument is to be furnished to analyze each sample stream. Vendor shall provide a field-mounted analyzer with solenoid actuated valves in sample-select manifold. Solenoid valves are to be manually operated from recorder in control room.
- Average barometric pressure 760 mm.
- Vendor shall furnish all accessory equipment to condition and regulate the sample except for pipe and pipe fittings. Vendor shall submit with quotation a drawing of complete sampling system showing all pertinent equipment, pipe sizes, and connection sizes. Vendor shall also submit with quotation a wiring diagram, complete with recommended wire sizes and shielding requirements, if any, for all electrical circuits between components that are to be wired by M.W.K. Pressure reducing equipment furnished by vendor will be installed at sample point by M.W.K. Co.
- Vendor shall state in quotation the following:
  - What effect the specified variations of each component will have on analyzer accuracy.
  - The percent drift of analyzer per 24 hour period.
  - The response time of analyzer (time for full scale deflection) and the resulting noise level in units of percent of chart record.
  - The extra utilities that purchaser must supply for proper functioning of analyzer such as water, air for purging, etc.
- Vendor shall submit with quotation his recommendations for ½ year supply of zeroing and calibrating gases and required accessories such as reducing valves.
- Above to be suitable for 125 volt, 50 cycle, single phase.

**TABLE II PURCHASING SPECIFICATION — DATA LOGGER AND ALARM SCANNER**

**I. GENERAL**

- A. Scope
  1. This specification together with the requisition and data sheets covers the requirements for Data Handling System.
  2. Supervision of Installation: a. Bidders shall state the number of man days of installation supervision which are included in the system price; and b. Cost per man-day for additional installation supervision.
  3. Start-up assistance.
  4. Manuals, diagrams, etc.
  5. Availability of service.
  6. Performance test, accuracy test and guarantee: a. Vendor is to make a performance test prior to shipment equivalent to 30 days of uninterrupted operation. The test period shall begin again after any corrections in design or maintenance for repairs.

**II. MARKING, SHIPPING, AND REJECTION**

**III. DESIGN**

- A. General
  7. Data handling system shall consist of a 200 point data logging system and 130 point alarm scanning system separate and independent of one another except for the pneumatic-electric transducers.
  8. Means shall be provided to permit the use of either analog digital converter unit with either or both the logging system and the alarm scanning system.
  9. Types of Inputs: a. The following type of inputs are to be introduced to the measuring and comparator circuits: (1) Temperature in form of millivolt signals from thermocouples. System shall be suitable for use with grounded or ungrounded thermocouple inputs. (2) Pressures in form of 3-15 psig pneumatic signals from pneumatic transmitters. (Linear or square root as specified on data sheets.) (3) Electrical signals from switch closures—110 volt 60 cycle current. Where contact closures are specified, the electrical circuit will be energized.
  10. Handling of the Output Signals: a. The output of the digital converter in the loggers is to actuate: (1) One or more electric typewriters as required by the number of points to be logged, and (2) The tape punching device furnished as a separate device to handle all points. b. The output of the digital converter in the alarm scanner is to operate its own electric typewriter.
  11. Pneumatic to Electric Transducers: a. An individual transducer shall be supplied for each pneumatic input; b. Readily accessible zero and span adjustments shall be provided on each transducer.
  12. Integrators: a. Each variable which is to be integrated shall be provided with a separate self-contained integrator. The integrator shall be readily removable and shall be interchangeable with other integrating units; b. Integrated flows shall be integrated hourly with a 24 hour total.
  13. Scale-Factor Adjustments: a. Scale factor adjustments shall permit setting of the full scale digital output by an adjustment directly in terms of the digital value. It shall not be necessary to dwell on a specific input in order to change the full scale digital value.
  14. Measurement Digitizing System: a. The measuring digitizing system shall have an accuracy of plus or minus 0.25 percent of full scale; b. The analog to digital converter shall have an accuracy of one in 1,000 or better.

15. Readout Devices: a. Typewriters are to be interchangeable with each other and are connected to the main cabinet by means of cables with plug connections.
16. Typewriter Desks: a. (1) Controls for entire data handling system are to be located on one desk....
17. Materials.
18. Interchangeability: a. All essential parts including removable units are to be made interchangeable physically and electrically with corresponding items or parts without drilling, filing, etc.
19. Bulkhead Connections and Pneumatic Piping: a. Provide tee connection with block valve as a test connection in each tubing line between block valve in cabinet and transducer or other pneumatic instrument.
20. Electrical Terminals and Wiring: a. All wiring to be suitable for installation in Class 1, Division 2 Group D location as defined by the National Electric Code; b. All terminal connections shall be suitably labeled; c. All equipment must be adequately grounded.
- B. Logging System
  21. The logging system is to provide periodic, on demand, or as a result of certain emergency conditions, automatic logging of a number of process variables. All variables shall be printed out in digital form on a log sheet.
  22. Frequency of Readout: a. A switch is to be provided so that the readout interval may be varied from continuous in 15 minute intervals to a maximum of once per hour.
  23. Readout Requirements for Data Logger: a. All variables shall be logged as instantaneous, integrated, or compensated values in the periodic log; b. The system after printing the check digit shall proceed to log the variables in a single line in the appropriate position at the rate on one variable per second approximately; c. All inputs shall be direct reading. Multipliers of 0.01, 0.10, 1.0, 10, 100, 1,000 are permissible; d. A preprinted log sheet shall be used for logging.
  24. Tape Punch.
  25. Digital Clock.
- C. Alarm scanning system
  26. Frequency of Scanning: a. Simultaneously with the logging and independent of the logging, a selected number of the input signals are to be continuously scanned at the rate of 5 points per second.
  27. Alarm Scanning: a. Each input shall be compared to its own high and/or low limit set points; b. If any input exceeds the limits the measuring circuit is to be activated and the readout device will print at the rate of 1 point per second; c. All points in the scanner are to be supplied with an alarm contact for each high and each low limit set point to close each time that input is detected as exceeding the alarm setting and also to close the contact if a switch closure is detected so as to actuate the alarm light and the common alarm howler furnished by others.
  28. Scanner point identification.
  29. Scanner readout requirements for points being logged: a. The scanner is to scan and print only instantaneous values regardless of which type of variable is logged.
  30. Scanner Readout Device: a. Unless otherwise specified the electric typewriter shall be of the same carriage width as the typewriters furnished in the logging system so that the units are all interchangeable.

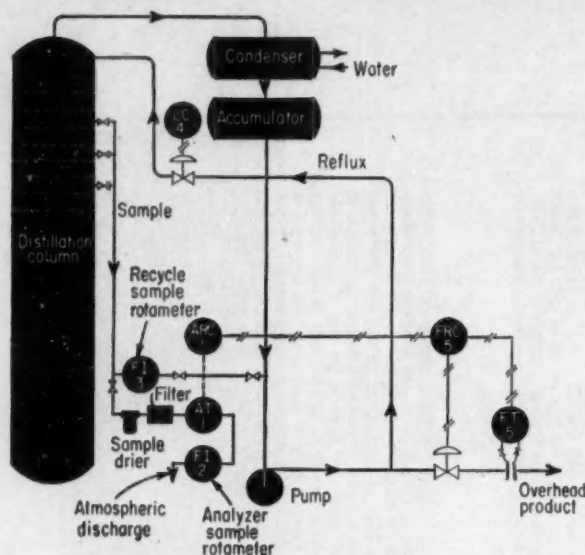


FIG. 3. Typical, but abbreviated, piping and instrument drawing showing process equipment, piping, and instruments. Instruments like the level controller (LC) can be procured by a simple purchase requisition, but complex instruments like the analyzer transmitter (AT) requires a more detailed spec.

America has developed a group of work sheets which are contained in "RP 20.1—Specification Forms for instruments, gages, thermocouples, orifice plates and flanges, control valves, and pressure safety valves."

After all the facts in previous specs are combined, a work sheet for a control valve looks something like this (abbreviated) example:

Fluid	WATER	(1)
Corrosive materials	SALT	(2)
Valve $\Delta P$ at max flow, psig	35	(3)
Max flow, gpm	150	(4)
Min flow, gpm	10	(5)
Line size, in.	2	(6)
Valve size, in.	2	(7)
Valve characteristic	EQUAL-PERCENTAGE	(8)
Positioner required	YES	(9)
Body material	CAST IRON	(10)
Trim material	MONEL	(11)

The entries in the above work sheet are derived as follows: Lines 1 through 5 are specified by Process; Line 6 by Piping; Line 7 is calculated in accordance with procedure in the Engineering Standard; Line 8 comes from Lines 4 and 5, which show wide flow rangeability and, according to the Engineering Standard, demands an equal-percentage characteristic; Lines 9 through 11 are also determined from statements in the Engineering Standard.

### The horizontal pattern

The minimum information transmitted to the

vendor varies from a two-line purchase requisition for common instruments to a 20-sheet writeup of function, performance, and construction for complex and costly systems. In general, the detail contained in a spec depends on what instruments or control system is being purchased:

**Class I** instruments can be characterized as common and frequently used control devices produced by many makers under official and quasi-official industry standards. Their function and operating characteristics are well-understood by competent instrument engineers. The vendor does not need to know the overall process conditions or applications problems. Typical of such instruments are controllers, indicators, recorders, transmitters, valves, gage-glasses, and thermocouples, all of which can be found in great variety in general catalogs. For a given device, there is considerable similarity in function from make to make, so that in the selection procedure the user is concerned mainly with cost, quality of construction, and future performance. A brief purchase requisition, based on the maker's specification, could suffice to buy one of these instruments, although—as pointed out—certain users still prefer to prepare their own specifications.

**Class II** instruments differ from Class I mainly in being more complex and in having unique process conditions and operating requirements that the maker must understand. Typical of Class II are such devices as stream analyzers and electromagnetic flowmeters. Class II instruments are commercially available, but they must be adjusted and modified for particular applications and locations. The purchasing spec and the work sheet transmits this special information. Prior to writing a final spec, the user may engage in technical negotiations with several makers to see what they have and what modifications (and at what cost) are needed to suit the application. Some makers prepare a checklist of important facts to be supplied by the user; they are similar to the user's work sheets but reflect, of course, the maker's initiative in getting the pertinent information. An actual, but abbreviated, work sheet spec for a gas analyzer is shown in Table I.

**Class III** instruments and systems generally are high in cost, complex, critical to successful plant operation, closely tied in with the selection of other plant instrumentation, and designed and built especially for the process. Typical are data loggers, programmers, graphic panels, and special control systems on trial for the first time. Here, the user does the preliminary engineering for the system, at least to the point of having his own ideas firmed up as to function and performance; he leaves other considerations, like exact physical size, design, and choice of components, to the maker. Thus, the purchaser must communicate to the maker considerable technical detail as well as his concept of what the system is to accomplish. An actual, but condensed, spec for a logger-scanner system is shown in Table II.

# How Design Simplifies Trouble-Shooting and Repairs

**THE GIST:** As more complex control and computing equipment becomes operational, maintenance can no longer be considered a necessary evil that is ignored until the first failure is encountered on the factory floor. Rather, the control system engineer must design for ease of maintenance just as he designs to meet performance specifications. Designing for maintenance has two aspects: 1) making it easy to locate the trouble, and 2) making it easy to repair it. The following covers many practical tips that are useful in both of these areas. Part II, to appear in a future issue, uses case histories to show that many control system manufacturers are making progress in easing the maintenance function.

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The control system that meets all performance specifications must still satisfy two other requirements for user acceptability:

1. it must be sufficiently reliable, so that it does not continually fail, and
2. when it does fail it must lend itself to repair in a reasonable amount of time by the type of maintenance personnel the user has available.

Downtime of the controlled equipment is not the only big cost; the maintenance operation is expensive in itself. Military records show that every dollar's worth of electronic equipment requires at least \$10 worth of maintenance before it wears out (Ref. 1). Although industrial figures are hard to come by, it's easy to visualize the total cost of maintenance running to two to three times initial equipment cost.

### **What does past experience show?**

While any type of production equipment requires maintenance, industrial electronic control systems require more than most. These systems are often complex and newly designed, the application may be new, the supplier may not be familiar with industrial design requirements (all his experience may be in military systems, for example), and the components he uses may not have been

intended to withstand the average industrial environment. The average user and his maintenance man are scared of these systems even before they have any experience with them because of their lack of familiarity and training.

Alan R. Davis points to the increase in electronic controls at North American Aviation, Los Angeles Div.: "Prior to World War II there were approximately 540 electronic tubes in operation, mostly in spot welders and process controllers. Maintenance consisted of trial and error replacement. If the trouble wasn't corrected by changing tubes, then we'd call for the manufacturer's field man."

"Today we have 2,800 tubes in operation. They are used in GE adjustable-speed drives on our spar and skin mills, Cutler-Hammer electronic drive controls on our two Gray skin mills, and Reliance VS drives on our Betts automatic skin mill. A year and a half ago, two Cincinnati Milling beam mills were delivered, each with six independent synchro-controlled servo loops. The most recent addition is the Numill with 600 transistors, 600 diodes, and 2,800 resistors on 250 printed circuit boards. Obviously trial and error maintenance will not suffice for this type of machinery." (Ref. 2)

Thus the number of complex industrial control systems is skyrocketing, not only in the now-conventional area of electronic adjustable speed drives and simple electromechanical servos, but in that involving such sophisticated systems as inventory control data processors, automatic warehousing equipments, pro-

gram controllers for machine tools, steel mills, and automatic testing systems, automatic production control and logging equipment, process control computers, etc. These are all compounding the maintenance problem.

To make this complex control equipment acceptable to the user is the joint responsibility of the control system designer, the controlled equipment designer, and the user himself. The designers can make the equipment more reliable and make it easier to find troubles and make repairs. The user can make sure that his maintenance personnel are properly trained and sufficiently familiar with the equipment so that they don't ignore it because they're afraid of it. Many perfectly good pieces of equipment are sitting around our factories, cold-shouldered by operators and maintenance men who were not given the opportunity for proper orientation.

### **How reliability relates to maintenance**

Much has been written concerning the design of reliable systems (see Ref. 3 through 10), so that little will be said about it here except to point out that reliability is only one of the many factors to be considered in evaluating a control system, particularly where ease of maintenance is critical. Military reliability experts have been tending towards a concept known as "systems effectiveness" or "how valuable is the equipment to you", in which reliability is only one factor. To quote H. A. Voorhees of Western Electric Co.: "Although mean

time between failures has been accepted as a key criterion of reliability, it doesn't tell how valuable the equipment has been to the users. Satisfaction from the use of equipment depends on many things, such as cost, performance capability, downtime, repair time, effects of redundancy, and effects of operating conditions and environments. These factors differ in importance depending on the

type of system involved." (Ref. 4)

This concept clearly applies when designing for reliability and easy maintenance, for the two design goals often conflict. For example, the most reliable circuit (in which all connections are solder joints, screw terminals, or some other form of permanent connector) is often the most troublesome: the downtime required to change a component or

subsystem can be unbearable. Consequently, plug-in modules are often used, although the pressure contacts tend to decrease reliability. Built-in fault-finding equipment also illustrates this point; it increases complexity (and decreases reliability), but is indispensable in the maintenance of complex gear.

This article deals with ways of simplifying repairs and trouble-shooting.

## Designing systems for easy repair

The first thing that comes to mind is modular plug-in construction. This usually simplifies repair (and often trouble-shooting as well), but has two disadvantages: it reduces reliability somewhat by adding pressure contacts, and increases circuit complexity (1 to 2 percent in typical military systems and probably a lot more in industrial applications). Figures 1 through 4 show the details of some typical modules.

The "package within a package" module from a Beckman Model 112 computer-data system uses printed wiring and solid-state components only, Figure 1. Maximum flexibility and ease of maintenance are achieved by the double plug-in arrangement. Figure 2 shows the cast-case construction and plug-in module loosening-jack design of the Voldicon voltage-to-digital converter manufactured by Adage, Inc. The cast case reduces construction costs and the printed wiring plug-in boards assure easy maintainability. Figure 3 shows another facet of this equipment: the guide pins are coded by rotating the male and female halves, making it impossible to put a board in the wrong slot.

Identifying the different modules is extremely important. Some color code the handle or front of the module, others remove an unused terminal on the plug-in connector, while still others use variations of the Adage technique. Figure 4 shows one of these variations on a GE welder control: here the pin and receiving hole placement are varied on different type modules (Ref. 11).

In designing unitized modules, make sure that the circuits or components are grouped logically. In a parallel adder, for example, there are two flip-flops, two AND gates, and a delay associated with each digit. In constructing such a device the components for a single digit should be unitized. It also pays to develop a system that can use common circuitry throughout. The advantage in replacement units and inventory of spare parts is obvious.

Plug-in type construction is not limited to complete subcircuits, but is used with components, too. Both the GE and Westinghouse static-switching elements are of the plug-in type and can be locked in place (an important provision in any type module, particularly if it is subjected to vibration).

## PLUG-IN MODULES SIMPLIFY REPAIR

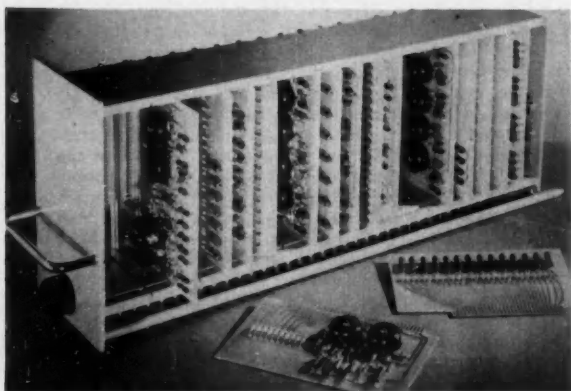


FIG. 1. Double plug-in arrangement means maximum flexibility and ease of maintenance.

FIG. 3. Rotating male and female halves of guide pins changes coding and prevents board from being inserted in wrong slot.

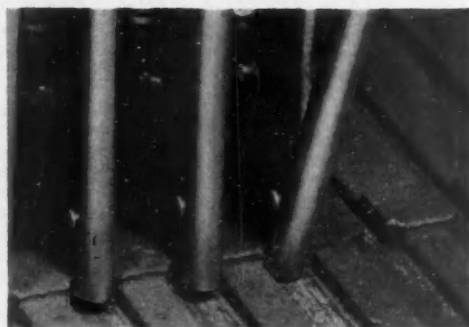
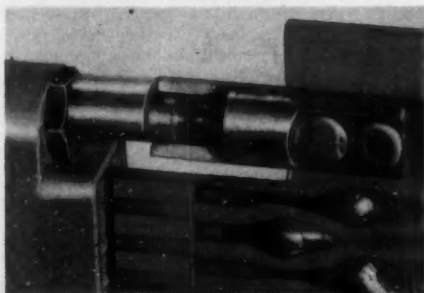
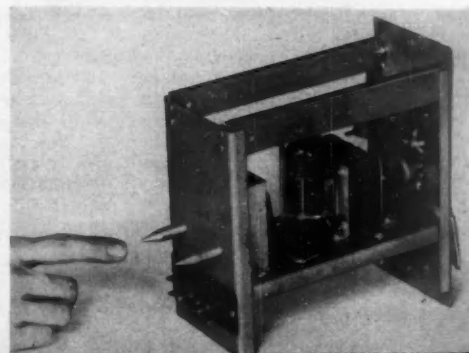


FIG. 2. Cast case holding plug-in boards yields simple rugged construction.

FIG. 4. Guide pin and receiving hole placement are varied for different modules.



## ACCESSIBILITY IS THE KEY

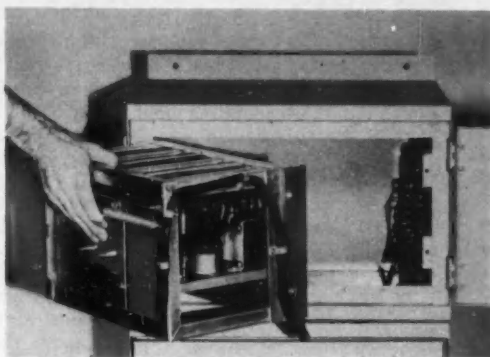


FIG. 5. Swing-out construction makes all components accessible.

The Ford Motor Co. has perfected a four-relay module as an aid to easy maintenance, reliability, and economy. It uses four conventional machine-tool-type relays mounted on a board that fastens to the panel channel, with the relay leads brought to a plug-type receptacle (instead of the mounting board itself plugging in). Again, each module board includes logical groupings of relays.

All behind-panel construction should be limited to cabling, and no components with a probably bounded life should be incorporated in this fixed portion of the construction. If this requirement is impossible, swing-out panels should be provided to give ready accessibility. Figure 5 shows this type construction on a GE resistance welder control.

Field maintenance personnel often complain about the effort required to replace wire internal to the equipment. Wire can be damaged by chafing or by accidental burning or cutting during repair, and sometimes it or its insulation is defective to start with. Standard harnessing and cabling techniques help here, but some form of wiring channel, such as the integrally built channel shown in Figure 6, is even better. Advantages of this type construction are: no lacing, bending radius of one wire is less than a group of wires, hidden or hard-to-get-at clamp nuts are not used, wire markings are visible, tracing is easier, etc. (Ref. 12).

Phenolic resin or bakelite wire channels, with and without equally-spaced wire openings, are on the market. These are as useful as integrally built channels, are probably much cheaper, and are readily available in various lengths. In connection with wiring practice, standard color coding should be used throughout.

One thing that wasn't mentioned under plug-in units is encapsulation. Here the complete circuit is potted in a nonconducting resin and the failure of one component usually means discarding the complete unit. This type of construction gives mechanical rigidity to the circuit elements and assists in heat dissipation; still, it is sometimes objectionable to industry because the entire circuit is lost if a cheap component fails.

One or two things should be said about repair of hydraulic systems. Most important, probably, is that the critical components are where they can be easily removed and where they can be observed for leaks. In one case a machine tool user replaced the steel cover plates giving access to the hydraulic servovalves with clear plastic plates. Not only could the maintenance per-

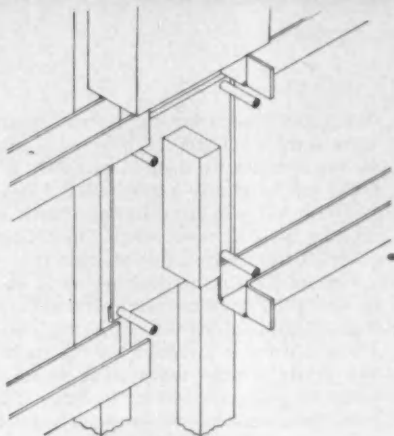


FIG. 6. Open wiring channels make tracing and wire replacement easy.

sonnel observe for leaks, but the plastic plates were considerably lighter than the steel ones.

Another thing: make sure that there is provision for bleeding air from the highest point in the system. This is necessary during startup and after extended shutdown.

While these are only a few of the improvements that can be made to assure easy repair, at least they give an idea of the direction to take. Now for the most important problem: finding the trouble.

## Designing for easy trouble-shooting

This is probably the most important—and newest—objective, as far as easy maintenance goes. As will be seen later, many suppliers have given considerable thought to it, and necessarily so, since it's extremely difficult for the average maintenance man to diagnose trouble in a complex electronic system.

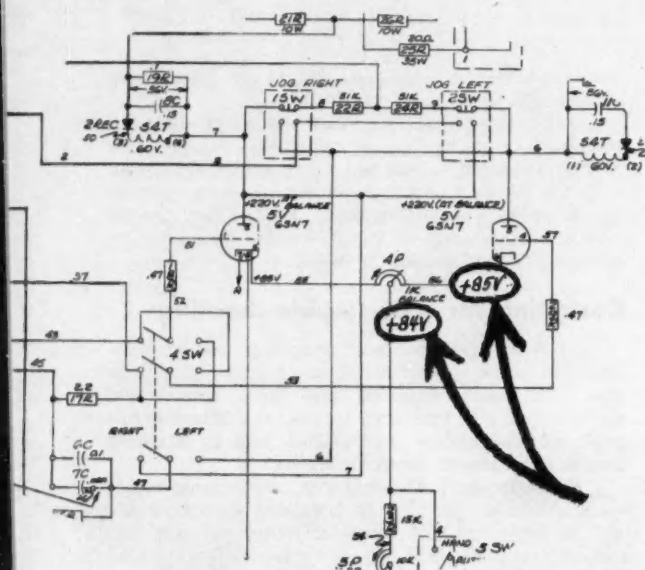
J. P. Seigler and J. M. McQueen, maintenance supervisors at the Georgia Div. of Lockheed Aircraft, relate that in their first few weeks of trouble-shooting the machine control unit on a numerically-controlled Bendix-K&T profile miller, between 90 and 95 percent of their time was spent locating the fault and only 5 or 10 percent in eliminating it. After they gained experience, fault-finding dropped to 80 to 85 percent, a figure that appears to be pretty well standard across industry and the military.

Alan Davis, North American Aviation, tells of an extreme case along this line. One of the machines was acting erratically, and the trouble was finally traced to a sensitive relay encased in a plastic sheath. The temperature rose in the control cabinet during the latter part of the day, causing the plastic case to contract and press on the relay mechanism. This upset the critical pickup point. The records show it took 4½ hours to locate the trouble and 5 sec to correct it (Ref. 2).

To get an idea of what might be done to reduce trouble-shooting time, look at how the military handles check-out and maintenance of its systems. Integrated automatic go/no-go test sets have been developed that exercise an entire missile control system, isolating and indicating faults on a go/no-go basis. These test sets measure such things as circuit continuity, supply voltages, bias, individual circuit operation, overall system dynamic response, etc., by programming the complete test from a stepping-switch or perforated-record programmer, applying the proper stimulus to each ele-

One of the first responsibilities of the supplier is to furnish good maintenance instructions. Figure 7 shows those furnished by GE with its Thy-mo-trol drives. These instructions should list the most likely troubles and clearly describe the possible sources (Ref. 14). System-wiring diagrams should include critical voltages and even waveforms for checking purposes. Figure 8 shows

IBM for example, uses three types of programs for checking out computers (Ref. 16). The first are system test programs. These are short, highly flexible routines



**FIG. 8. Wiring diagrams should include critical parameter values and waveforms.**

**GOOD MAINTENANCE  
MANUALS  
ARE A MUST**

**FIG. 7. Possible troubles and their sources should be clearly described.**

TROUBLE	CHECK
Motor does not run	<ol style="list-style-type: none"> <li>1. If tube filaments do not heat, use voltmeter to check power to panel and power to primary of filament transformer 3T and 4T.</li> <li>2. If tube filaments heat but field tubes do not glow after approximately one minute, check that relay XTR is energized; if not, check voltage on pins 2 and 3 of relay TR. Replace relay TR if necessary on transformer. If relay XTR is energized, check field tube connections and wiring of circuit composed of field tubes. Check external contact of relay TR. Check relay circuit composed of GL-866-A field tubes.</li> <li>3. If field tubes glow after approximately one minute, check field tube connections. Replace tubes 6 and 7 and allow time when "START" button is depressed. If correct value of resistor 20R is in use for horsepower rating of motor.</li> </ol>
Motor stops quickly after "START" button is depressed	<ol style="list-style-type: none"> <li>1. Check for open resistor DBR. Check diagrams to see whether jumper on resistor DBR should be removed for horsepower rating of motor used.</li> </ol>
Speed of motor "pulses" or "hunts"	<ol style="list-style-type: none"> <li>1. Reduce setting of IR-COMPENSATION potentiometer. Replace capacitor 9C, if defective, observing correct polarity.</li> <li>2. Check series-field connections on motor. They may be reversed.</li> <li>3. If "hunting" persists, replace capacitors 5C, 6C, 1C and 2C one at a time.</li> </ol>
Poor speed regulation	<ol style="list-style-type: none"> <li>1. Advance setting of IR-COMPENSATION potentiometer to flat-compound motor at desired speed. Note: Too much IR compensation will cause instability or hunting.</li> <li>2. If IR compensation is ineffective, current-limit circuit may be defective. Replace tube 6.</li> </ol>
Short tube life	<ol style="list-style-type: none"> <li>1. Tube life will be shortened by improper filament voltages, excessive ambient temperatures, severe vibrations, poor socket contact or improper handling or storage.</li> <li>2. If life of thyratron tubes is short, check for overload condition in addition to checks in preceding step. The average current conducted by each tube should not exceed 6.4 amperes over any 15-second averaging time.</li> </ol>

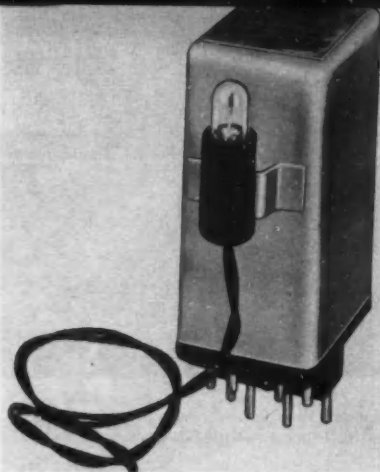


FIG. 9. Indicating lights help to find trouble, particularly in digital systems.

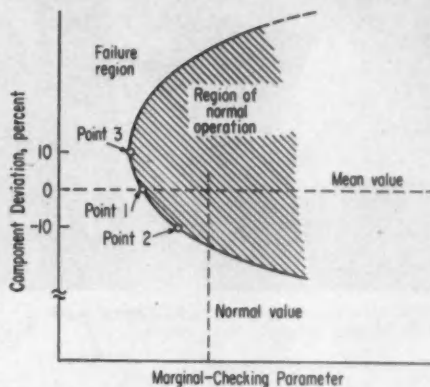


FIG. 10. Marginal checking is a powerful maintenance tool.

REPORT THE FAILURE OF ONLY ONE PART OR TUBE ON THIS FORM				REPORTS CONTROL SYMBOL CSGLD-803	
1. REPORT NO.		2. REPORTING ACTIVITY		3. REPAIRED OR REPORTED BY (Name)	
4. EQUIPMENT INSTALLED IN (Type and No.)		5. TIME METER READING OR INSTALLATION LOG TIME		6. OPERATIONAL CONDITION	
7. EQUIPMENT		8. MODEL DESIGNATION AND MOD. NO.		9. CONTRACTOR	
10. COMPONENT (Major Unit)		11. MODEL DESIGNATION AND MOD. NO.		12. CONTRACTOR	
13. ASSEMBLY OR SUBASSEMBLY		14. SERIAL NO.		15. MANUFACTURER	
16. PART NAME OR TUBE TYPE		17. STOCK NO. OF FAILED ITEM		18. PART REF. DESIG. (V-101, B-101, etc.)	
19. HOURS IN SERVICE		20. MANUFACTURER OF FAILED PART		21. SERIAL NO.	
22. FIRST INDICATION OF TROUBLE		23. CHECK TYPE(S) OF TUBE OR PART FAILURE		24. WAS REPLACEMENT PART AVAILABLE LOCALLY? YES NO	
25. INOPERATIVE		26. ARCING		27. CAUSE OF FAILURE	
28. INTERMITTENT		29. BEARING FAILURE		28. FAULTY PACKAGING	
29. LOW PERFORMANCE		30. BENT		29. WISDOMING	
30. NOISE		31. BENDING		30. INSPECTION OR TEST	
31. OFF FREQUENCY		32. BROKEN		31. NORMAL OPERATION	
32. OUT OF ADJUSTMENT		33. BRUSH FAILURE		32. STORAGE	
33. OVERHEATING		34. BURNED OUT		33. ASSOCIATED FAILURE-EXPLAIN	
34. UNSTABLE		35. CHANGED VALUE		34. OTHER	
35. OTHER		36. CORRODED		35. WAS THE PART REPLACED DURING PREVENTIVE MAINTENANCE? YES NO	
36. OTHER		37. OTHER		36. OTHER	

FIG. 11. Good maintenance records help in failure prediction.

with a large amount of manual control. The primary purpose is to verify design, correct improper wiring, and analyze machine malfunctions. They are usually not used in maintenance because of long setup time.

The second class, diagnostic programs, attempt to pinpoint the machine malfunction to as small an area as possible. Upon detection of an error, the program will analyze what area is responsible, and will indicate this by printing out the information or by stopping at a particular location.

Reliability programs make up the third class. These perform a test as rapidly as possible, but make no attempt to locate the area of trouble. They are designed as a go/no-go type of test to rapidly check a large amount of equipment.

Another technique borrowed from the digital computer field is marginal checking. This is extremely useful in locating intermittent failures and in locating components that are likely to fail. The method is shown in Figure 10 (Ref. 17). The tolerance of one of the components in the circuit is plotted against the variation in the marginal-checking parameter. The designed operating point of the circuit is the intersection of the mean value and normal value dotted lines near the center of the parabola. This point represents normal voltage on the circuit and normal value of the

components. When the supply voltage or marginal-checking parameter is lowered, a point (point 1) is reached on the contour line where the circuit fails to operate. This is the point at which the function of the circuit deviates from that of the prescribed specification. In a flip-flop, for example, the point at which some standard pulse fails to switch the state may be failure. If the component deteriorates by 10 percent, the voltage only has to drop to point 2 before a failure occurs. Thus marginal checking combined with some kind of a test routine that exercises all of the circuit elements provides a powerful trouble-shooting tool.

Another good procedure is to physically number all dynamic elements in a complex control system and keep a faithful record of failures and difficulties. Over a period of time this will assist in predicting failures and in establishing preventive maintenance routines. Figure 11 shows an electronic failure report used by the armed services. This may be too complicated for industrial use, but it at least furnishes some useful ideas.

A commercially-available trouble-shooting device widely used in the automotive industry is the Electro-Graphic Detector System, designed and manufactured by W. F. & John Barnes Co.'s Electrical Div. This combines both the indicating light and test-point techniques to simplify trouble shooting of complex switch-

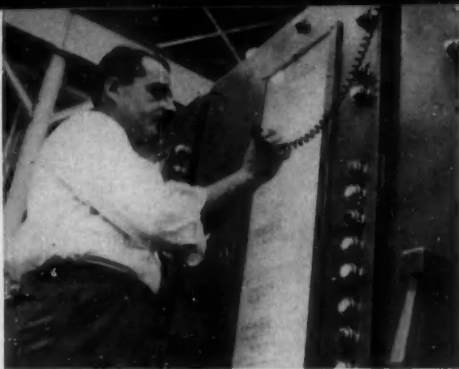


FIG. 12. Electro-Graphic Detector System speeds fault locating on relay control systems.



FIG. 13. Where system elements are widely separated, an integrated telephone system helps in finding trouble and during calibration.

ing circuits (Ref. 18). Figure 12 shows a typical panel. Test leads are brought out from the actual circuitry to schematic wiring diagrams, and white and blue sequence-indicating lights are mounted alongside the wired-in diagrams. If the lights stop sequencing, the equipment has malfunctioned in that part of the circuit straddled between the white and blue lights. The actual failure can be located by running a test lead over the circuit points in the troubled area.

Cutler-Hammer does the same thing with a telephone dial. Dialing connects critical points in the circuit to a test lamp to indicate whether a point is energized.

Special test equipment is often helpful, particularly with special types of control devices. For example, Bendix supplies a packaged tester for servicing the individual plug-in units in its numerical control system. The maintenance people at Lockheed Georgia report that it takes 10 to 15 min. to find a fault in one of these units with conventional test equipment, and only about 1 min with the special tester. Westinghouse supplies a special phase indicator with its phase-sensitive Cypak system, and GE General-Purpose Controls has developed a special test box for its static control systems.

Some of these techniques can be applied to hydraulic systems. Pressure switches connected to critical portions of the systems, for example, can indicate high and low pressures and pressure differentials. A differen-

tial pressure switch across a filter indicates when the drop is too great and the filter is clogged.

In many installations, such as in steel mills, the control cubicle may be placed in a location far from the process machinery and operator's station. Positive communication between the cubicle and the operator's station is essential during calibration and equipment adjustments. As shown in Figure 13, Industrial Nucleonics Corp. solves this problem by providing an integrated telephone system.

A large variety of trouble shooting aids are available, even going so far as automatic test routines that rigorously check out all portions of a system. What technique to use depends on the particular application, but go/no-go routines that do not require manual judgment are almost always best, if they are possible. The second part of this article offers several case histories to show what's being done.

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# Ball Bearings for Precision Gyros—

*how they affect your system's performance*

**RICHARD H. CHERWIN**  
New Hampshire Ball Bearings, Inc.

Today, miniature ball bearings costing as much as 300 dollars a pair are being used in commercial gyroscopes. Offhand, this seems like a pretty high price to pay for such simple, unsophisticated components. Unfortunately, there is no substitute for precision. Just as a chain is only as strong as its weakest link, the performance of a modern inertial guidance system is only as good as the precision of its gyroscope bearings. In fact, the slightest imperfections in these bearings could produce output errors large enough to render an entire system useless.

## Rotor bearing problems

In a gyroscope, rotor spin axis bearings and gimbal bearings perform essentially the same function. The rotor shaft, however, turns at 10,000 to 20,000 rpm, or higher, while the gimbals rotate only a few degrees at relatively low speed. Thus performance of rotor bearings is considerably more critical than that of the gimbal bearings. Three factors which seriously affect this performance are: friction in the bearings, elastic deformation of both rotor and bearings, and thermal expansion or contraction.

### Friction

Ideal rotor bearings maintain an absolutely fixed relationship between the gyro rotor axis and the inner gimbal, under all operating conditions. They also offer zero resistance to the turning of the rotor. Unfortunately, "full-race" ball-bearing construction allows the balls to rub against one another, creating friction, to which must be added the coulomb friction caused by the balls rolling on a curved raceway. Further, since all points on the ball-to-raceway con-

tact areas are not equidistant from the ball's rotational axes, a certain amount of slipping will occur.

### Deflection and thermal effects

Serious errors in gyro output also result from elastic deformation of rotor bearings. Whenever a gyro undergoes an acceleration, the center of gravity of its rotor shifts against the applied force. Unless this shift is along the original force vector, the force will produce a moment about the axis of the inner gimbal, causing the gyro to precess and indicate an erroneous change in gimbal position.

Differential thermal expansion or contraction of mating parts is still another problem that demands the close attention of the instrument designer. That which constitutes a satisfactory fit at one operating temperature may become too loose or too tight at some higher or lower temperature, in which case cross-coupling or friction may become excessive.

### Practical solutions

After considerable study, it was found that the type of ball bearing that comes closest to meeting the requirements for spin axis application is the so-called Conrad bearing. This type contains a ball retainer that prevents the balls from rubbing against one another, as occurs in the full-race construction. Although some friction is generated by ball against retainer and retainer against the OD of the inner ring, satisfactory minimum torque is maintained. Normally in an inertial gyro, bearing friction torque should not exceed 70 dyne-cm.

As far as materials are concerned, steels such as 52100 chrome and 440C stainless appear to be the

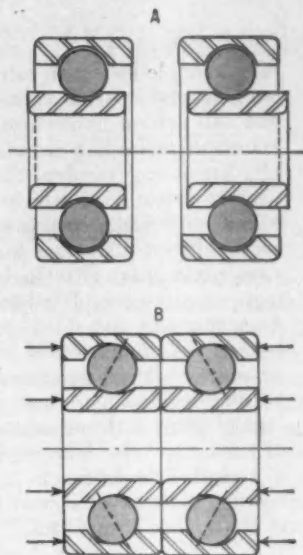


FIG. 1. A pair of bearings for one end of a gyro rotor shaft A) before preloading, and B) after preloading.

most suitable for use in instrument bearings. Since steel, however, has a certain amount of elasticity, and will deform under load, a mounting technique known as preloading is used. Performed at assembly, preloading involves the application of a permanent thrust load which causes the bearings to operate on a flatter portion of their deflection-vs-load curves. Figure 1 shows a pair of bearings before and after preloading. Residual elasticity in the bearings prevents a completely fixed relationship between rotor spin axis and inner gimbal, but accurate preloading will minimize this condition. Thus, a given amount of preload represents a compromise between bearing stiffness and low running torque. Most current gyros with miniature bearings use a preload of from 1 to 5 lb. The curve in Figure 2 represents a typical load-deflection curve for a single ball bearing. Note how the curve flattens with an increase in the applied thrust load.

In a gyro, the rotor itself represents an elastic body; fortunately, its deflection characteristics can

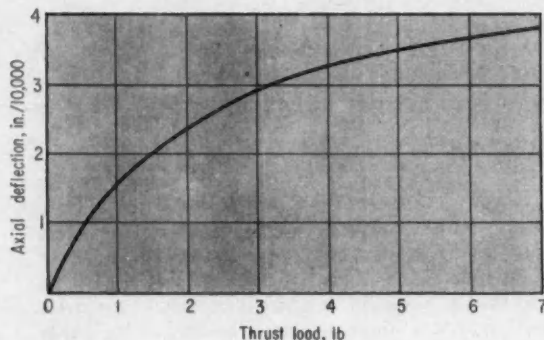
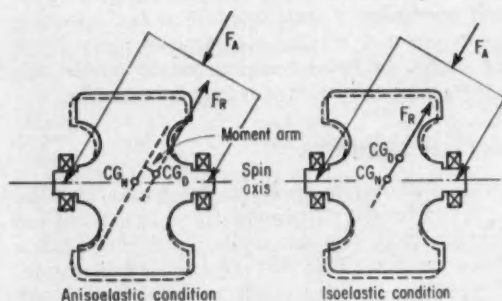


FIG. 2. Typical thrust load vs axial deflection curve for a single bearing.



$CG_R$  = Normal rotor center of gravity and inner gimbal axis

$CG_D$  = Deflected rotor center of gravity due to acceleration

$F_A$  = Vector showing direction of external force producing acceleration

$F_R$  = Vector showing direction of reaction force due to inertia

— Deflected position  
- - - Normal position

FIG. 3. Force acting on a deflected isoelastic structure is not displaced from its original line of action.

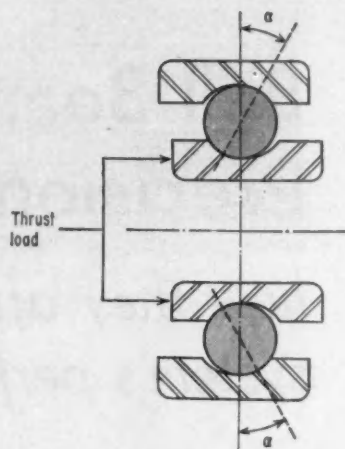


FIG. 4. Contact angle formed by the application of a pure thrust load.

be designed to counterbalance those of the bearings, thereby approaching an "isoelastic" condition. The rotor-plus-bearings combination is said to be isoelastic when the rotor's center of gravity, under acceleration in any direction, shifts along the line of the applied force. Figure 3 illustrates the difference between this and the anisoelastic condition. With the isoelastic design, the applied force continues to pass through the axis of the inner gimbal, even after the center of gravity shifts. Thus, having no moment arm, the force can produce no error.

Deflection characteristics of a given ball bearing depend on four parameters: 1) ball size, 2) number of balls, 3) raceway curvature, and 4) contact angle. Of these, the first three are easily controlled in the design and manufacturing stages. Contact angle, however, is determined at the assembly of the bearing by controlling the amount of free radial play. As shown in Figure 4, contact angle is measured while the bearing is subjected to a pure thrust load, and is the angle between a line normal to the bearing axis and a line passing through the points at which a ball touches the raceways. Typical rotor-plus-bearing assemblies become isoelastic at contact angles of 20 to 30 deg.

Housing and shaft fits also influence gyro performance. Tight interference fits, by compressing the outer ring or expanding the inner ring, reduce the contact angle, and thus alter the bearing deflection characteristics. A good rule of thumb is to strive for line-to-line fits on both diameters. Actually, a fitting tolerance of plus or minus 0.0001 in. provides satisfactory performance in most applications.

Finally, to avoid differential thermal expansion, with its attendant increase in cross coupling or friction, materials used for shaft, housing, and bearings must be carefully selected so to have equal or nearly equal expansion coefficients.

# JOURNAL OF APPLIED CONTROL DEVICES THAT NEVER WEAR OUT

For Control Engineers Who Are Wearing Out Before Their Time

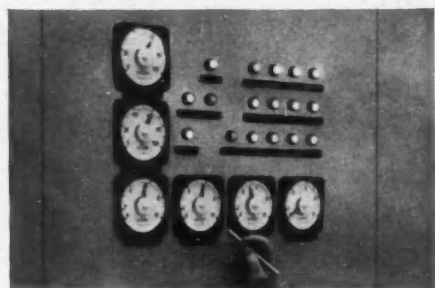
## ALCOA DISCOVERS WONDERFUL NEW WORLD OF INDUSTRIAL TELEMETERING

Aluminum Company of America engineers have just cut the cost of measuring large amounts of direct current used in smelting operations by replacing conventional meter-and-shunt arrangements with CONTROL's transducers. Beyond cost-cutting, the installation at Alcoa's new plant at Massena, New York, sets new highs in operating reliability, convenience and safety. Telemetering of a hot 8,000 amperes at 600 volts is done over a

distance of several hundred feet, with no direct connection to the bus bars which carry the heavy current! The CONTROL transductor is in essence a d-c current transformer, and unlike the meter-with-shunt, it can be used for remote measurements, regardless of distance—and still retain its guaranteed  $\pm 1\%$  accuracy. *This is static control, and it's based on high permeability magnetics. A transductor catalog awaits your request.*



At Alcoa: Technician inspecting CONTROL transductor, one of 48 measuring 8,000 amperes at 600 volts.



At Alcoa—Several hundred feet away: Readings are taken on both individual transducer meters and totalizing meter.

### STATIC CONTROL= TRANSDUCTOR = SIMPLICITY

What appeals to engineers (Alcoa and otherwise) about CONTROL transducers is their simplicity. Two Orthonol® (nickel-iron alloy) cores are connected electrically in opposition, the bus bar runs through them, and you have the world's simplest device for measuring large currents over long distances. No need for calibrated leads (as with meter-and-shunt). They are comparatively easy to cut into the line—mount like donut current transformers. The transductor loops around the bus and is not even directly connected to it! Alcoa sums the readings from several transducers measuring different bus lines simply by feeding their outputs into a totalizing transformer. Potential differences of the lines being summed have no effect. *Our catalog shows the simple circuitry, and details the full range of transductor sizes from 200 to 25,000 amperes. Write for your catalog.*

### ALL THIS ... AND THE RIGHT PRICE, TOO!

We're selling a lot of transducers. It's their flexibility that catches the customers. *To wit:* Variations in ambient temperature, or stresses on the bus bar as the building settles have no effect on accuracy. *To wit:* They provide a usable power output: you can run relays and magnetic amplifiers directly from the transductor with no booster amplifier. *To wit:* Additional accessory meters can be easily added at a later time. *To wit:* They install easily. You open the line, slip on the CONTROL transductor, reconnect—and the job is done. *And—they are competitively priced! The higher the ratings, the less they cost compared to competitive methods. Prices and complete information await your immediate request.*

Reliability begins with **CONTROL**

A DIVISION OF MAGNETICS, INC.

DEPT. CE-66, BUTLER, PENNSYLVANIA

CIRCLE 81 ON READER-SERVICE CARD

AUGUST 1959

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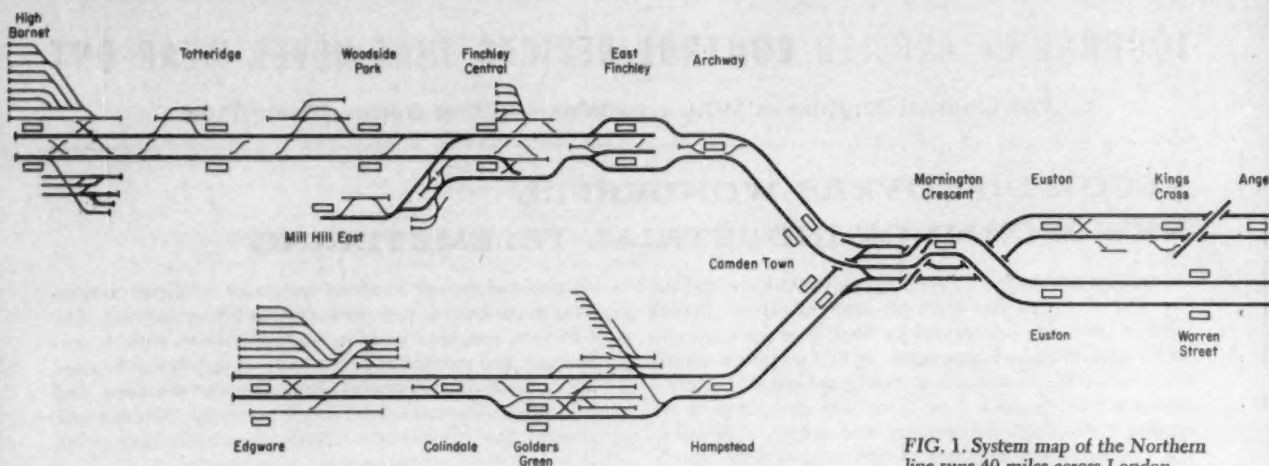


FIG. 1. System map of the Northern line runs 40 miles across London, and has two large junctions at Camden Town and Euston through which 1,300 trains pass each day.

## Punched Tape Controls London Trains

R. DELL, Signal Engineer  
London Transport

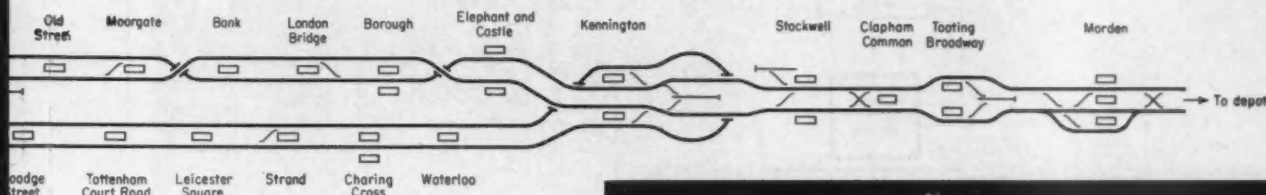
On London's Underground, punched-tape programmers control the movement of 1,300 trains a day through the junctions of the complicated Northern line. The destination and time of arrival of each train in the rapid transit system is automatically checked against a recorded timetable; then switches and signals are set to properly guide the train into and out of the junction. The program machines allow for out of turn operation, should trains on any one branch be behind schedule.

The Northern line, the most complicated trackage on the London Underground (rapid-transit) system, is making successful use of program machines for fully automatic signaling and switching of trains at junctions. Figure 1 is a map of the line, which includes two main branches that originate at the north end of the city. The branches meet in a large junction at Camden Town, then separate again to pass through the center of London along two routes. One moves through downtown and the other through Charing Cross. The lines meet once more at Kennington, where there is a reversing loop and a siding, and narrow to two tracks that extend to the southern terminus at Morden. A total of 650 trains per day travel in each direction on the center section between Camden and Kennington.

For many years the line has been equipped with train "describers", which give information on train destination to passengers and signalmen at the junctions. As each train leaves the terminus, its description, in the form of a four-wire code, is sent down the line by the signalman. At each station and signal tower, the code is stored in receivers until the particular train arrives. The train describer employs an electromechanical drum with storage capacity for 32 coded descriptions.

In 1955, Camden Town junctions were converted to automatic operation; the train description was then used to initiate setting of the track switches at the converging and diverging junctions on a first-come, first-served basis. Experience showed that this

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arrangement was not satisfactory, because a train arriving at a junction only a few seconds early would be signaled out of turn. This led to the introduction of the new program machines, which perform the followings functions:-

1. Signal all trains over the correct routes when the service is running correctly.
2. Check arrival time of all trains and sound an alarm if any train is more than two minutes late.
3. Check the train identification on the describer unit to make sure that it agrees with the timetable.
4. If trains on one branch are late, signal other trains that may be waiting. Information on the delayed trains is stored so that they can be automatically signaled through when they appear.

The Kennington junction was the first to be operated by program machines; installations were added later at Camden Town and Euston, so that now the whole center section of the line functions without signalmen. The same mode of control will be extended to the junction at East Finchley.

### Operation

The program machines, Figure 2, carry a strip of plastic material, 8 in. wide and about 8 ft long, wound on two rollers. The rollers are driven by a small electric motor through magnetic clutches that permit the roll to be moved in either direction.

The roll is indexed to the required read positions by the combined action of the clutches and an electric brake.

The information for each train (time, route, and final destination) is contained in coded form in a row of holes arrayed across the plastic roll. The same information is also typewritten alongside each row of holes. A group of 32 metal feelers read the program by completing electrical circuits through the holes. These feelers are raised from or lowered against the program roll by a small compressed air cylinder controlled by a solenoid valve. Interlock contacts are provided to insure that the feelers are withdrawn before the roll moves. A photocell scans a separate line of holes to position the roll correctly for each reading.

The automatic control of each junction requires the use of two program machines, one for sequence programming and the other for timing. The sequence-program machine steps once for each train that passes and is quite independent of time. This is the unit that actually initiates the setting of the track switches and the clearing of the signals. It insures that every train is correctly dealt with, regardless of whether it is early or late.

The timing machine is similar to the sequence-program unit in design, except that the electrical circuits for stepping the roll are controlled by time. The time interval between successive trains is coded into a set of punched holes on the program roll. Thus, the machine, in addition to carrying the

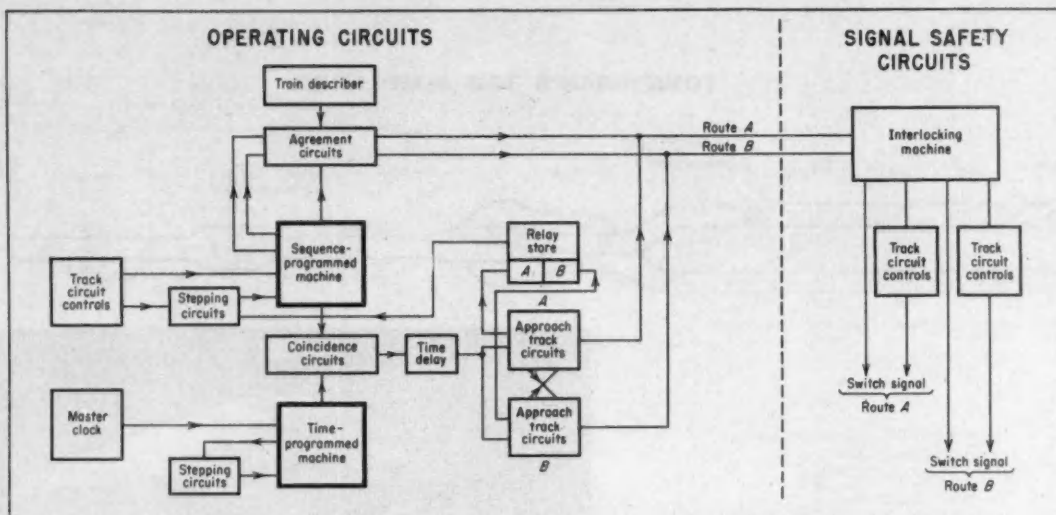


FIG. 3. Block diagram of automatic train-programming system. Safety circuits for interlocking the switches and signals of the system are shown at right.

switching and signaling data for a train, also contains information on the time interval between it and the preceding train on the timetable. A master clock delivers one pulse to the programmer every 30 sec. These pulses are counted until the total number equals the time interval between succeeding trains, whereupon the timing machine advances its roll one step.

In this arrangement, the two machines are nearly always one train out of step, the sequence unit being one step ahead of the time unit. It is only at the actual moment the train is due that the time machine coincides with the sequence machine. This coincidence provides a time signal to the sequence machine to indicate that a train is due. If the service is late, the time signal activates a warning circuit. The signal could also be used to start the departure

of a standby train from a siding to the station platform, if train is later than a predetermined time.

In normal operation, the program machine signals the trains strictly in accordance with the timetable punched on the sequence program roll. As each train approaches, the destination shown on the train describer is checked with the destination on the program roll. If these agree, the signals clear immediately. If there is a disagreement, the program machine delays signaling the train for one minute and sounds an alarm in a central supervision office. If no countermanding action is taken by the office personnel, the sequence machine routes the train in accordance with the train description. A push-button is provided in the central supervision office so that the machine can be instructed to signal the train according to the program roll if the train description is thought to be in error.

The diagram, Figure 3, is a schematic of the programming control. The signal safety circuits are separate from the program circuits and are incorporated in electropneumatic interlocking machines that are standard on all the London Transport lines. These machines, designed for pushbutton operation, have mechanically operated contacts that interlock all signaling and switching equipment to prevent unsafe functioning. The circuits of the program machine terminate in electropneumatic valves that control rotation of the shafts of the interlocking machine. Contacts on the shafts pick up the safety circuits.

In the normal routine of automatic operation, the track circuit controls indicate the physical presence of a train to the sequence program machine. The latter checks the train describer for agreement, then sets the appropriate route. After the passage of the train, the track circuits initiate the stepping of the program roll to set up the next route. If a train fails to arrive on time, however, the coincidence

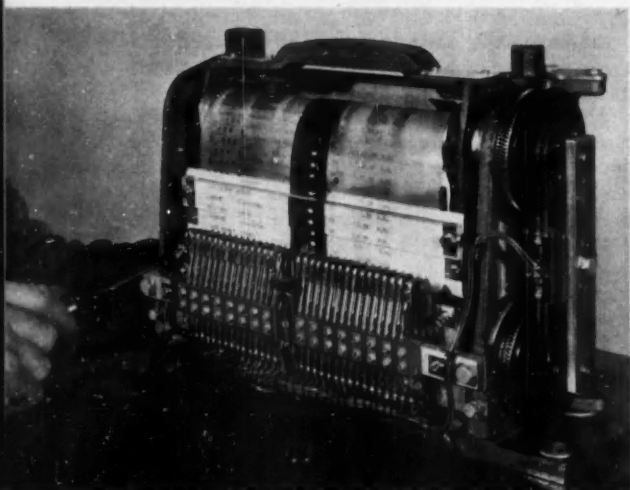


FIG. 2. Plastic rolls on the program machine carry coded and typewritten details of each train route, time, and destination.

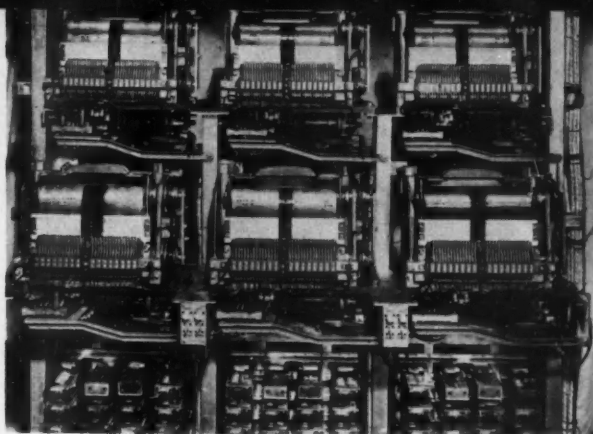
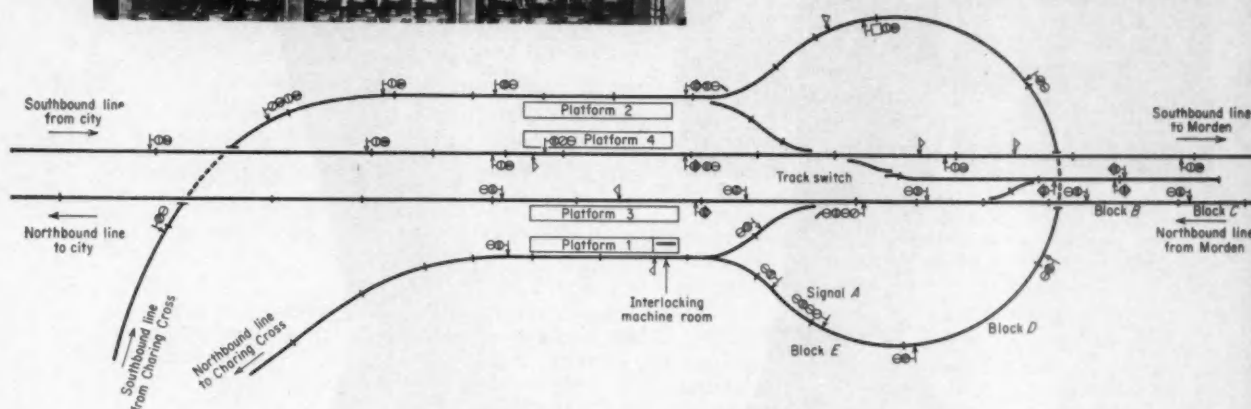


FIG. 5. Installation of six programmers at Kennington station. The two units on the left are the time-operated machines.

FIG. 4. Details of track and platform layout at Kennington.



network checks along the approach track circuits after a two-minute delay. If the train is still missing, the machine sets the appropriate out-of-turn route and records an "A" or "B" signal in the relay store to denote the route on which the train has failed to appear. The output contacts of the storage relays inhibit the stepping of the program machine until the delayed train appears. When it does, circuits from the relay store establish the proper route. The passage of the late train diminishes the count in the store; normal operation is resumed when the store is empty indicating "on time" conditions.

### Installation

The diagram, Figure 4, shows the layout at Kennington station. Here, four sequence and two time-program machines, Figure 5, control service to the four platforms. Platform 1 and the loop junction leading to it are controlled by one machine. Trains can enter this platform directly from Morden in the south via track switch A. When Kennington is to be the terminus for southbound trains, the cars approach via the reversing loop, ready for return northbound. The program machine normally operates the signals to bring trains into the platform in their programmed order. In the event of some interruption to the service on the line from Morden, the program machine keeps this route open for two minutes beyond the arrival of the signal from the time machine. It then checks along the track circuits (blocks B and C) for the programmed train. If it is not present, the track circuits in the loop

(block D and E, signal F) are interrogated to ascertain whether a train is waiting in the loop. The route would then be set up by signal F to bring the waiting train from the loop into the platform, ahead of its turn on the program. Information on this out-of-turn operation is stored and the program machine prevented from stepping. The relay store allows up to five trains to be sent ahead out of programmed order. As soon as the train from Morden appears on the track circuits, the relay store immediately brings it into platform 1. Departure of this train reduces the count in the store; each successive train from Morden is signaled through until the store is cleared.

The central supervision room at Leicester Square station, in the center of the line, is equipped with repeater machines, which are identical to the program units except that the feelers are disconnected. The repeaters are synchronized with the programmers at Kennington and the other junctions by means of a separate row of holes on the roll. The typed information on the repeater rolls gives the supervisor details of the train service throughout the line. At the central control, four buttons are provided for each machine to deal with emergencies such as train cancellations. When control is advised that a particular train is canceled, its position on the program roll is checked and the appropriately numbered button pressed. Relay circuits in the programmer count the trains passing through; when the deleted number is reached the machine steps twice, passing over the canceled train.



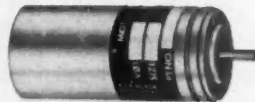
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# Some Dc Current Relationships in Transistors

ALBERT N. DeSAUTELS  
Maico Electronics, Inc.

Control systems in general have an innate need for direct-coupled dc amplifiers. Basic to the development of transistorized dc amplifiers is an understanding of the dc current relationships in the transistor. Here are some of these dc current considerations in ready reference form.

The pnp and npn junction transistors of Figure 1 can be regarded as a pair of diodes with a common connection. One of these diodes, biased in the forward direction, represents the emitter-base junction. The other diode, biased in the reverse direction, represents the collector-base junction. The reverse current of the inverse-biased collector-base junction is controlled by the forward current of the forward-biased emitter-base junction. The general relationship for the dc currents in the transistor under these conditions is

$$I_e = I_b + I_c \quad (1)$$

With no current flowing through the emitter base junction, a leakage current  $I_{co}$  flows through the collector base junction. This leakage current, not controllable by the emitter, is related to the amplitude of the inverse voltage between collector and base, and is extremely temperature-sensitive. The total collector current,  $I_c$ , consists of current due to carriers transferring from the emitter, plus the relatively small leakage current. The transfer of carriers is in the ratio  $\alpha I_e$ , where  $\alpha$  (nearly unity) is the dc short-circuit gain of the common-base connection (base common to input and output circuits, as in Figure 1). Therefore,

$$I_c = \alpha I_e + I_{co} \quad (2)$$

or from Equation 1

$$I_b = I_e (1 - \alpha) - I_{co} \quad (3)$$

Another important relationship is

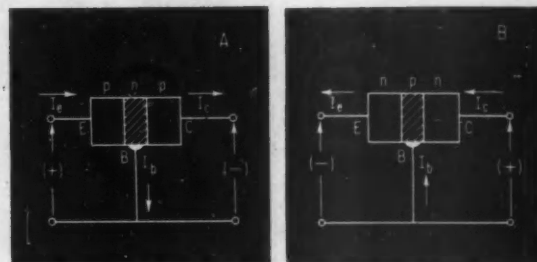


FIG. 1. A—Pnp transistor must be biased with voltages of polarities indicated; currents then flow as shown. B—Npn transistors require opposite bias, have opposite current directions; but, absolute dc current relationships are identical with pnp's.

$$\alpha = \frac{\beta}{1 + \beta} \quad (4)$$

where  $\beta$  is the dc short-circuit current gain of the popular common-emitter connection. It is useful to express each of the direct currents in terms of the remaining two and the common-base current gain  $\alpha$ , or the common-emitter current gain,  $\beta$ . These relationships can be obtained from the expressions of Equations 2, 3, and 4, and are tabulated in Figure 2.

The current directions shown in Figure 1 represent true directions, and the general relationships of Figure 2 are applicable to either pnp or npn junction transistors using absolute current values. Figure 3 is a conversion graph for the short-circuit current gains of the common-base and the common-emitter configurations.

FIG. 3. Ready-reference plot of relationship between  $\alpha$  and  $\beta$ .

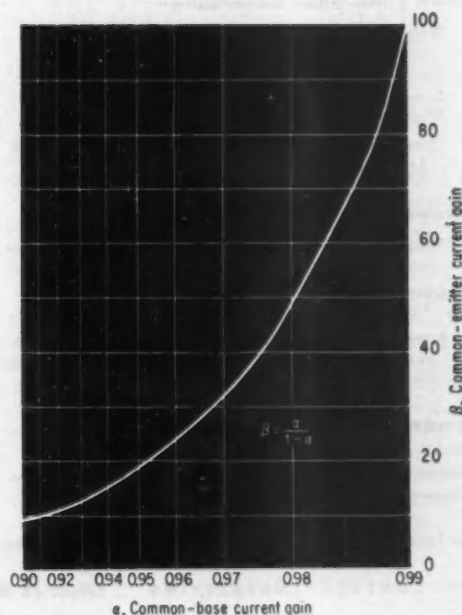


Fig. 2 DC Current Relationships

	$I_b$	$I_c$	$I_e$
$I_b$	$I_b$	$\frac{I_{co}}{\beta} - \frac{I_{co}}{\alpha}$	$(1-\alpha)I_e - I_{co}$
$I_c$	$\beta I_b + (1+\beta)I_{co}$	$I_c$	$\alpha I_e + I_{co}$
$I_e$	$(1+\beta)(I_b + I_{co})$	$\frac{1}{\alpha}(I_c - I_{co})$	$I_e$

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# Comparators for Use in Automatic Evaluation Systems

**THE GIST:** Performance comparison is the key. Whether you're checking out the complex control system on a missile or testing and inspecting equipment flowing from a production line, the object is to compare actual characteristics or performance with desired ones, preferably in an automatic go/no-go manner that doesn't require operator judgment. In the August 1958 issue of CtE, author Klivans described five widely different automatic testing systems. This time he pinpoints the key item in these systems, the comparators, and discusses typical optical, mechanical, thermal, and electronic methods of automatically comparing static and dynamic characteristics. Also listed are typical commercially-available devices that can be used to make up these comparators.

**L. S. KLIVANS**

**Radioplane, a division of Northrup, Inc.\***

In an automatic evaluation system such as the one shown in Figure 1, the comparator takes the desired value of a performance parameter, as entered into the system from the programmer, and compares it with the actual value as obtained by test. For the parameter to be acceptable, the difference between actual and desired must fall within a tolerance band established by the programmed instructions. If the parameter is out of tolerance, the system normally alerts an operator to make an adjustment or to reject or replace the equipment under test.

The type of comparator that is used in these systems depends on the type of phenomenon being evaluated, the required accuracy, and the justifiable reliability and cost factors. The basic forms of comparison in which a meter, oscilloscope, or recorder, etc., is read by a human operator who then compares the value against a check sheet or other reference, are not discussed. The types of comparators that are of interest are those applicable to semi-automatic or fully automatic check-out equipment, where the difference quantity is monitored with respect to a preset tolerance band and an audible or visual signal, or a printed record presented to the operator. This indication is only of the go/no-go or lo/go/hi variety. The comparators covered here make use of optical, mechanical, thermal, and electrical operating techniques.

## Optical, mechanical, and thermal comparators

Optical comparators monitor system performance by using a light source and by replacing the human eye with a light-sensitive detector. Many different system

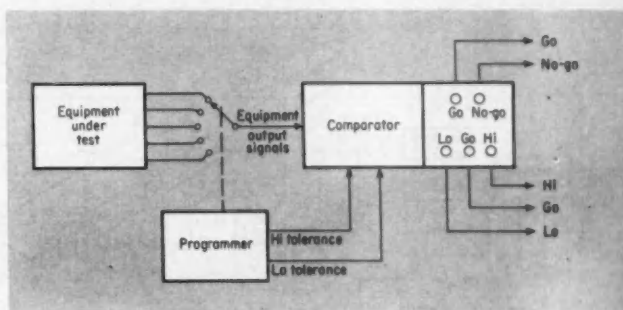


FIG. 1. Simplified diagram shows function of comparator in automatic evaluation systems.

parameters can be evaluated by means of photocells, oscilloscopes, and the newly developed solid-state light-sensitive devices. Figures 2 through 4 show typical optical comparators that are recommended primarily for low-cost production-line flow monitoring, or for verifying the dynamic performance of audio and radio-frequency control systems.

Mechanical comparators are limited primarily to monitoring changes in such variables as position, velocity, torque, force, and pressure. Only purely mechanical devices are covered under this category; electromechanical comparators are included in the electronic classification. Thus mechanical comparators are limited to mechanical or pressure switches operated directly from a mechanical output of the equipment under test. Figures 5 and 6 show typical units.

To evaluate the performance of temperature-control systems, a restricted variety of thermal comparators can be used, as shown in Figure 11. This type of device uses temperature-sensitive elements, such as thermistors or thermocouple switches, that actually monitor the temperature being controlled. These are connected to give a bistatic indication of whether the

\* Now with U. S. Science Corp.

control system is operating within the prescribed limits.

### Electronic and electromechanical comparators

The most common type of comparator is electronic or electromechanical. Further segregation into analog or digital is possible, depending on the overall mechanization of the automatic evaluation equipment. The analog comparator is normally simpler, less costly, and more reliable, while the digital variety is far more versatile and more accurate.

The most common analog comparator consists of relays with a buffer amplifier for isolation and power amplification. Figures 7 and 8 show typical units. The relays can be replaced with numerous types of electronic switches, such as thyratrons, diodes, transistors, vacuum tubes, or magnetic amplifiers, Figure 9, if high-speed comparison is required. Figure 10 shows another common analog comparator, one that uses an electromechanical chopper-type modulator plus difference amplifiers operating relays. This configuration is recommended for comparing dc signals, since drift is eliminated and regulated power supplies are not required.

These electromechanical and electronic analog comparators can readily be extended to handle any type of

parameter—frequency, pressure, position, velocity, etc.—by providing the comparators with transducers to give a proportional voltage.

The difficulty of programming accurate analog tolerance settings to the above types of comparators can be overcome by going to a digital comparator. This works particularly well for automatic evaluation systems that use punched-card, punched-tape, or magnetic-tape programmers. The tolerances are inserted into the comparator using coded information prespecified into the programmer. Extremely accurate comparison is possible; the difficulty arises in converting all of the parameters being evaluated into a suitable digital form. Figure 12 shows a typical digital comparator.

The table following the figures lists typical commercially-available comparators and equipment that can be used to custom-design comparators.

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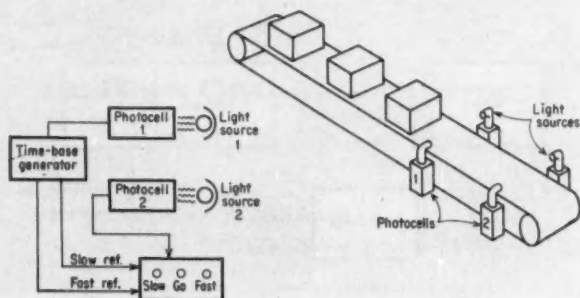


FIG. 2. Production-line flow-speed comparator using photocells. Base speed is established by the frequency at which photocell 1 is interrupted. Time-base generator sets a tolerance on either side of this base speed. Indication is slow, go, or fast, depending on where the frequency at which photocell 2 is interrupted falls with relation to tolerance band. Technique can be used to check holdup in a process or approximate synchronization of two production lines.

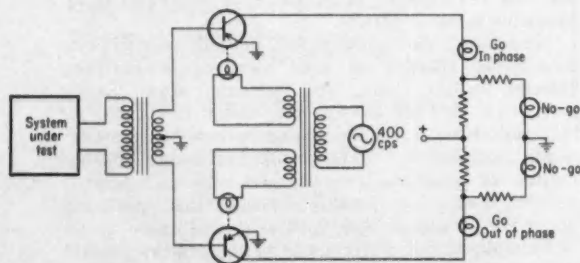


FIG. 4. Signal phase comparator using photo-sensitive transistors. If the output signal from the system under test is exactly in phase with the reference, the top transistor conducts and the in-phase go lamp lights; if exactly out of phase, the bottom transistor conducts and the out-of-phase go lamp lights. Intermediate phase relationships are indicated by the no-go lamps.

### OPTICAL COMPARATORS

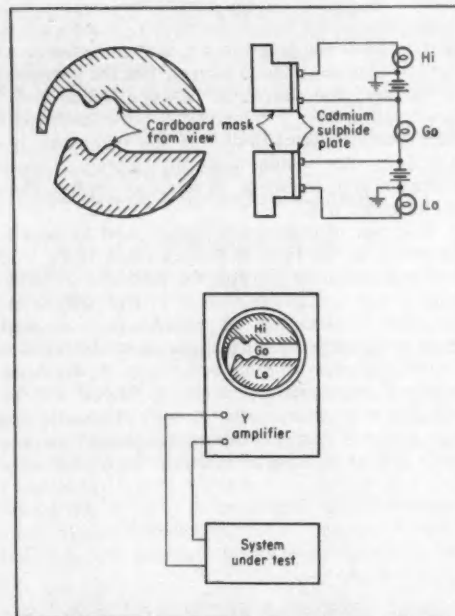


FIG. 3. Optical comparator using oscilloscope and light-sensitive cadmium sulphide plates to check transient response of control system. Cardboard mask of the proper shape covers the go region, so that if the system responds correctly, the go lamp remains lit. Response outside of go region exposes cadmium sulphide plates to light from oscilloscope trace and energizes either hi or lo lamp.

## MECHANICAL COMPARATORS

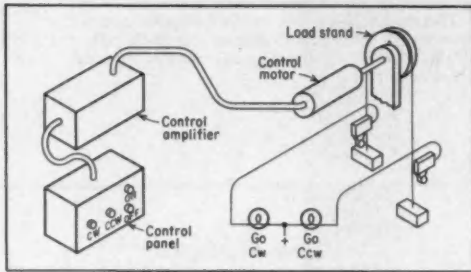
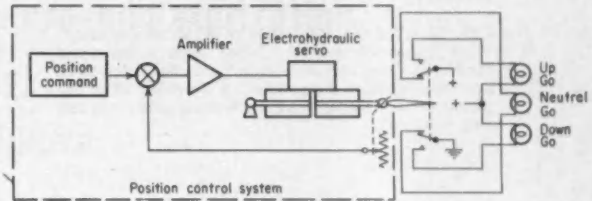


FIG. 5. Straightforward mechanical-position comparator used to check three specific output positions of an electrohydraulic servo. Comparator gives go indications for the two hardover positions and for the neutral position; no-go in-between positions are indicated by none of the lights being lit. Simple switches do the job.

FIG. 6. Mechanical stall-torque comparator. In the arrangement shown here, calibrated force-sensitive switches indicate that minimum required stall torque is being exerted in either direction. No-go condition exists if the proper go lamp is not lit.



## ELECTRONIC AND ELECTROMECHANICAL ANALOG COMPARATORS

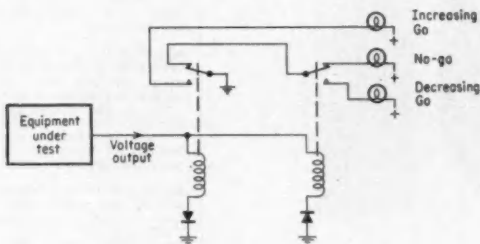


FIG. 7. Relays form electromechanical voltage comparator. When both relays are deenergized, a no-go condition is indicated. Go lamps light on proper increasing or decreasing voltage characteristics, with tolerance settings determined by the pull-in voltage adjustment on the two relays.

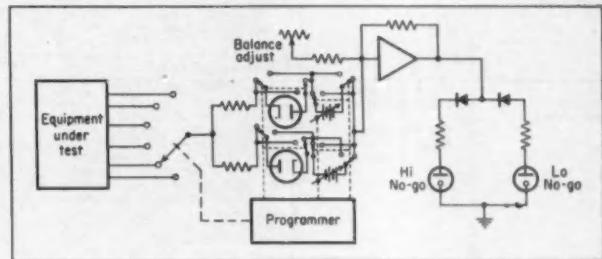


FIG. 9. Electronic voltage comparator using dc operational amplifier. Programmer selects the proper output terminal of the equipment under test while at the same time adjusting the internal parameters of the comparator to yield the correct rejection tolerance signal. A comparator such as this can be made considerably more flexible and precise than a relay type unit (but it is considerably more expensive).

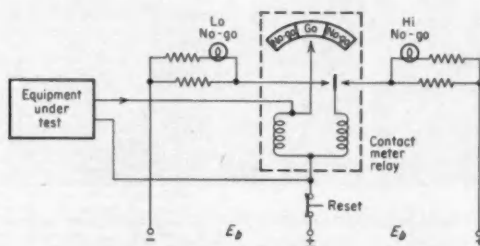


FIG. 8. Electromechanical voltage comparator using commercially-available contact meter relay. The upper and lower tolerances can be manually adjusted on the meter. In this configuration, the meter remains locked in the no-go-hi or no-go-lo position once either out-of-tolerance contact is made. Reset button returns meter to normal if voltage condition has been corrected.

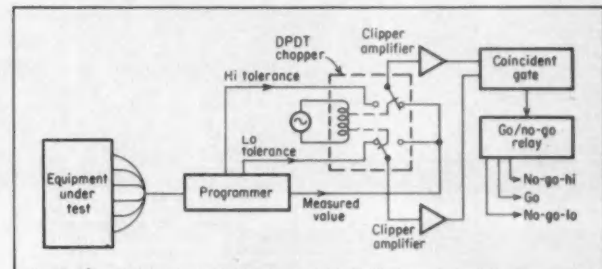
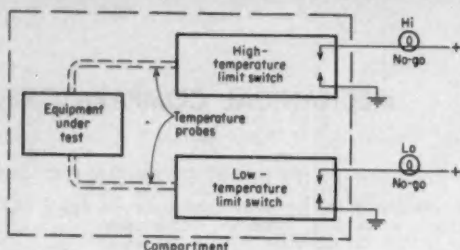


FIG. 10. Electronic voltage comparator using a suppressed-carrier chopper modulator. At any one time, modulator output feeds measured value to coincident gate on one channel and either high or low tolerance value on the other channel. Thus, the measured value is alternately compared with the two limits of the tolerance band. The relay responds in accordance with this comparison.

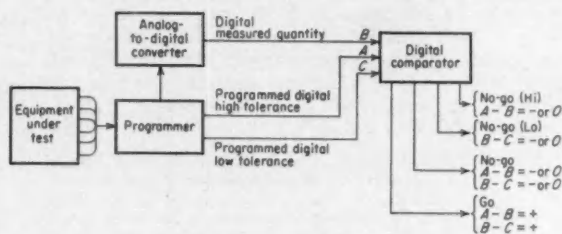


## THERMAL COMPARATOR

FIG. 11. Temperature comparator used for monitoring safe operating conditions for equipment under test or for on-line systems. Thermostat, thermistor, or thermocouple actuated temperature limit-switches close to indicate excessively high or low conditions. Satisfactory operating environment is present when neither lamp is lit.

## DIGITAL COMPARATOR

FIG. 12. General configuration of a digital comparator. These comparison systems can be made accurate and flexible; but they cost more than the analog comparators, and there is always the problem of converting all of the parameters that are measured on the equipment under test into digital form.



## Typical Commercial Comparator Assemblies and Building Blocks for Comparators\*

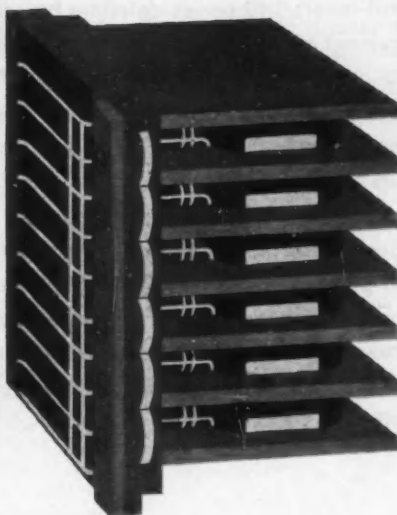
Classification	Manufacturer and part number	Description and remarks
Electromechanical voltage or current analog-type comparator (contact meter relay)	Assembly Products, Inc. Palm Springs, Calif. Model 461-C	Indicating meters with built-in relay contacts. One contact is carried on the moving element of the meter; the other contacts on adjustable pointers. Numerous sizes, ranges, and contact configurations are available for ac and dc current and voltage. Also available are thermostat-actuated meter relays for temperature comparison.
Optical comparator (photo-relay)	Sigma Instruments, Inc. South Braintree, Mass. Cdc Photo-relay Model 1	Intended for light/no-light applications. A Sigma Type 41 spdt ac relay is combined with a broad-area cadmium sulphide photocell. Contact rating is 3 amps resistive at 115 volts ac for 100,000 cycles. Operates at 5 foot-candles and releases at 0.1 foot-candles at 115 volts ac. 50/60 cps, 25 deg C. Operate and release values inversely proportional to source voltage. Two operations per sec guaranteed. Peak response with tungsten light source at 2,854 deg K is 5,000 to 6,000 Angstroms.
Thermal comparator (thermostat)	Valverde Labs. New York 12, N. Y. VAL 90 Miniature thermostat	Precision-set, reliable, miniature thermostat. It is of the friction-couple, snap-action, minimum-differential type, with a capacity of 40 watts at 30 volts ac or dc, or 100 watts at 120 volts ac or dc. Settings to 300 deg F are available, with accuracy of plus or minus 3 deg F and differential of 3 deg F.
Lo-go-hi analog-type voltage comparator	Pomona Div., Marquardt Aircraft Co. Pomona, Calif. Model 1121	Used to determine whether test voltage is above, below, or within acceptable tolerance band. Tolerance settings are adjustable from plus or minus 0.17 percent to plus 100 percent, minus 50 percent, with five different limits available. The unknown voltage must be between 5.0 and 20.0 volts dc. Reference voltage requirements are 10 volts dc plus or minus 0.03 percent at 10 milliamps. Input impedance is 1.0 megohm and response time is 0.25 sec.
Differential-error-detector analog-type comparator	Pomona Div., Marquardt Aircraft Co. Pomona, Calif. Model 1122	This instrument is used to determine the magnitude of the error between the unknown test signal voltage and a highly accurate standard reference voltage. Comparator output is linearly proportional to the difference. The unknown voltage can range from 0 to 20 volts dc, and input impedance is 1 megohm. Evaluation accuracy is plus or minus 0.1 percent or 10 millivolt. Any input signal from 10 volts plus or minus 0.2 percent to 10 volts plus or minus 10 volts dc, and an output current of 10 milliamps at 10 volts dc is available.

Classification	Manufacturer and part number	Description and remarks
Digital elements for developing comparators	Navigation Computer Corp. Philadelphia, Penn.	Model 113A four-input amplifying OR tri-unit contains three individual OR circuits, each having four inputs and two amplified outputs. Both positive and negative 10-volt output signals are available. Model 117A exclusive OR tri-unit performs the logical functions of exclusive OR or material equivalent.  Model 113 tri-input amplifying-gate, decode unit consists of 10 individual gates, each with three inputs and an amplified output. A 10-input OR circuit is also included for mixing one to 10 outputs on a common bus. In addition, there is a common amplifier for driving from one to 10 gates simultaneously.  Model 115A pulse standardizer tri-unit is used primarily to convert pulses from any standard source into standard 2.5-volt microsec pulses for the other NAVCOR units. There are three standardizing flip-flops with automatic reset and a 2.5-volt pulse standardizer. Other modules include pulse generators, binary counters, shift registers, and pulse delay units.
Digital elements for developing comparators	Ransome Research San Pedro, Calif.	Several types of plug-in, transistorized, printed-circuit digital computer elements are available. All are on standard 4 1/2 x 5 in. cards with connection by a 22-pin printed circuit connector. All units are rated for at least 500 kc operation, with higher speeds available. Basic elements include: Series A3 and A4 dc logical gates. The gating circuits consist of an AND gate and an OR gate. All gates are provided with emitter-follower outputs to avoid loading the output and input. These two series are adequate for most gating and control problems, but special units can be provided for unusual applications. The A3 units have five gates each with three AND inputs. The five gates are connected in various AND/OR combinations. The A4 units have four gates each with four AND inputs. The four gates are connected in various AND/OR combinations. Also available are binary-decimal counters, flip-flops, and shaping amplifiers.
Complete digital comparator	Pomona Div., Marquardt Aircraft Co. Pomona, Calif. Model 1123	Compares digitized response data from a system under test with upper and lower digital reference signals from an external reference unit. The comparator will handle 12 bits of information for each of the references and for the unknown data. The shift rate is 50 kc and a 20-volt peak-to-peak pulse with an input rise time of not less than 1 microsec is required. Comparison accuracy is one out of 12 bits, and relay contacts are provided to indicate go, no-go, no-go-lo, and no-go-hi.

\*This list only samples commercially-available devices than can do the job; there is no intention to be complete. Further, widely used devices such as thermistors and precision switches are not mentioned even though they are very useful in automatic evaluation systems.



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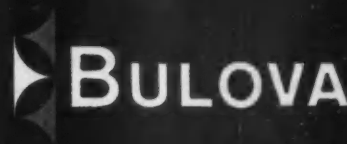


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# Applying the Digital Computer to Open-Hearth Operations

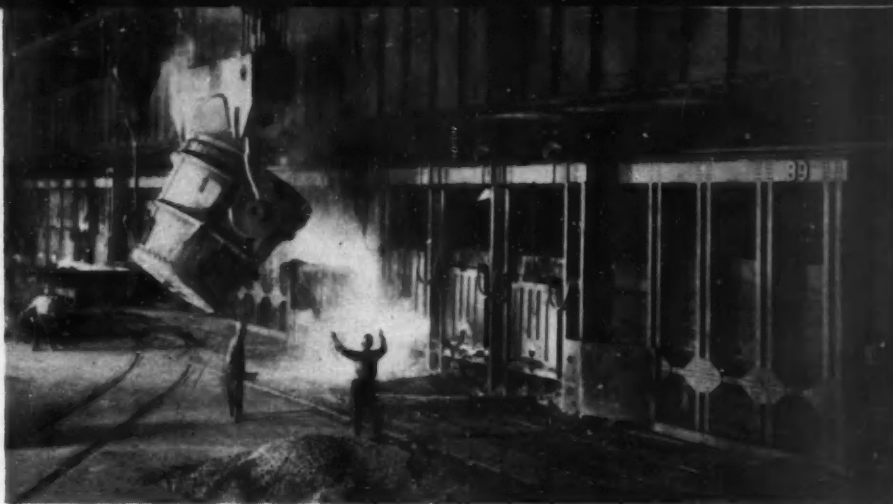
This article is based on an engineering proposal prepared by GPE Controls, Inc. for several steel companies. The proposal describes how to apply a digital computer and its electronic automatic control instruments to open-hearth furnace operations. The proposal covers 140 pages detailing function, construction, and operation of each instrument and control device, and explaining how this equipment is integrated into a control system capable of improving furnace operations. Its publication here, in abbreviated form, will be of value to engineers and management investigating computing-control. The proposal represents hundreds of engineering man-hours spent in analyzing process operation, consulting users, and designing the system. The application is a specific example of using a computer for plant control, yet much of the information contained herein, for example the section on English programming in which the user defines process operation for the computer, can be extended to other processes. For the steel industry, installation of such a computer-logger system will be a major step toward eventual closed-loop control. Other industries may be able to more immediately use the computer for closing the loop. HRK

## Engineering Staff, GPE Controls, Inc.

An open-hearth shop contains 10 to 20 furnaces, each furnace operated by a melter and his helpers. Scheduling and production is directed by a shop superintendent. Open-hearth production of steel is a batch process, a heat taking about eight to 10 hours. Furthermore, the open-hearth process is regenerative; two halves of the furnace (checkers) are used alternately. Heat energy stored in one checker—which has been tapped at the completion of its heat—raises the temperature of the combustion air for the other checker and thereby increases furnace efficiency. The regenerative operation is automatically carried out by furnace reversal control, one of many controls for each furnace.

Each furnace has its own automatic control sys-

tem and central control panel. The operator manages his furnace with these instruments independently of other furnaces, setting furnace variables and observing process conditions. Causes of delays, cost of fuels, knowledge of furnace characteristics, and similar information are important to the shop superintendent in getting maximum efficiency from his shop. He needs up-to-date information on furnace operations to schedule production. The data processing capability of the digital computer, tied in with the automatic control system for each furnace, can give him this information quickly and automatically. One computer can serve many furnaces, 12 in the present case. The computer also provides a fixed schedule of heat sequences as standardized operating guides, and sounds alarms if the allotted times are exceeded. The computer does not reset controllers, although there is some feedback from the computer to controllers and operators.



## AUTOMATIC CONTROL SYSTEM FOR THE OPEN-HEARTH FURNACE

The open-hearth automatic control system maintains furnace conditions set by the operator. Panel-mounted indicating and control instruments, set-point stations, trend recorders, and selector switches centralize information for the operator. Signals from furnaces also go to a computer-logger, which give shop supervisors typed records during, and at the completion of, each heat. Built-in failsafe features promote safety.

The ability of the control system to maintain operating conditions during the heat contributes to furnace efficiency and smooth operation. Each controlled variable affects furnace performance in a different manner. Their control loops, while described independently, form a complete, fully integrated system.

**Total Heat Input and Roof Temperature Control—**(Figure 1) Before roof temperature reaches its allowed maximum, the manually set heat input control limits total furnace heat input to an amount that can be efficiently absorbed by the charge and checkers. This reduces smoke stack losses to a minimum. When roof temperature reaches maximum, the roof temperature control generates a signal which bucks other summarizer amplifier inputs and automatically reduces manual heat input so that roof temperature is maintained within allowed limits. The control continually measures three roof temperature points and the computer (described later) determines the point with highest temperature and switches control to this point.

**Total Fuel/Combustion-Air Ratio and Waste-Gas Oxygen Content Control—**assures good combustion regardless of fuels used or firing rate. It meters directly burner fuels flow rates and combustion air, and indirectly, by waste-gas analysis, the amount of combustibles or oxygen liberated by furnace charge. The instruments provide two control modes. One is the conventional method of ratioing burner fuels flow rates to combustion-air flow rate; the furnace operator readjusts this ratio manually, using the waste-gas analyzer as a guide, to compensate for combustibles or oxygen liberated by the charge. In the other control mode, the operator sets the desired oxygen content in the waste gases. The automatic control then computes and maintains correct combustion-air flow rate to obtain desired waste-gas oxygen content.

**Fuel-Oil/Atomizing Medium Ratio Control—**main-

tains, regardless of firing rate, the ratio necessary for optimum fuel-oil atomization, thus assuring proper flame shape and optimum combustion. A switch selects either natural gas or steam as the atomizing medium. The same ratio set-point station is used for both atomizing mediums.

**Furnace Pressure Control—**maintains the ambient pressure over the hearth slightly above atmospheric pressure outside the furnace, to prevent infiltration of cold air or excessive loss of hot combustion products. Cold air cools the charge, so that more fuel is required to keep it at the desired temperature; it also increases the volume of combustion products and thus increases stack losses. However, too high a pressure causes excessive leakage around the seals of the furnace service openings, with subsequent damage to the brickwork. Repairing such damage increases furnace down time.

**Automatic Reversal Control—**promotes safety and

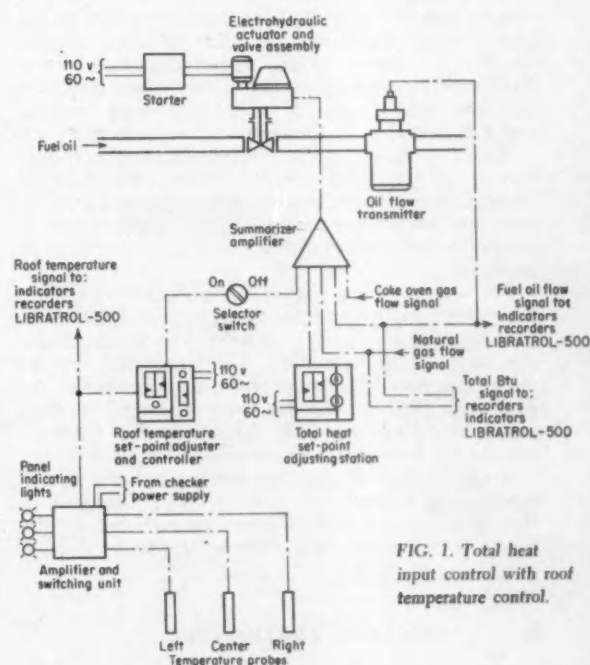


FIG. 1. Total heat input control with roof temperature control.

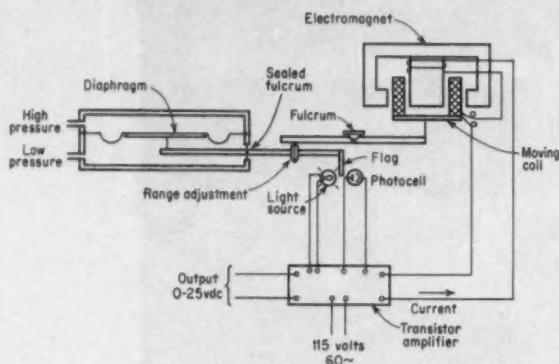


FIG. 2. Flow transmitter (for orifice plate).

improves furnace efficiency in four ways. This control:

- provides a correct and fully interlocked sequence of closing and opening reversing valves during reversal,
- provides a purge period, preventing explosions of air and combustible mixtures,
- reduces reversal time, allowing more time for firing, and
- controls firing time as a function of either checker temperature or fixed time. Normally, reversal is initiated by checker temperature, so that only the "cream" of checker heat is used—yielding high combustion-air temperature and thus high flame temperature.

**Coke Oven Gas Control**—maintains supply of coke oven gas, a supplementary fuel, at a flow rate set by operator.

**Metallurgical Oxygen Flow Control**—maintains supply of metallurgical oxygen at a flow rate set by the open-hearth operator.

### Electronic control equipment

The electronic control system consists of transmitters, controllers, actuators, indicators, recorders, and control panel. One feature of GPE Controls' electronic instruments is that the output of all transmitters is 0-to-25 vdc for zero to full scale. (For description and output signals of electronic controls from six other makers, see Ref. 1.) Signals of this magnitude are not interfered with by electrical noise. Furthermore, indicators and recorders—simple dc voltmeters—have uniform scales calibrated to fit the variable being measured.

**Transmitters**—are designed especially for heavy-duty service to withstand severe environments such as found in open-hearth shops. They measure flow, pressure, and temperature. For metering viscous materials, a positive displacement meter is coupled to a tachometer generator.

For measuring less viscous materials, a force-balance flow transmitter is connected across an orifice plate. This flow transmitter, Figure 2, provides 0-to-25 vdc output directly proportional to flow. The transmitter operates in this manner: Differential pressure applied across the diaphragm positions the flag with respect to the light source and photocell. The signal from the photocell goes to the linear transistor amplifier. Amplifier dc current output flows through the moving coil and electromagnet. As a result, the moving coil is attracted to the electromagnet with a force proportional to the square of the current. This force is transmitted through

the balance arm to the range adjusting wheel, which in turn applies a force to the diaphragm lever arm to balance the force exerted by it. The differential pressure developed across an orifice plate is proportional to the square root of flow; but the transmitter current is the square of differential pressure. As a result, the current is linear with respect to flow rate. (The pressure transmitter is similar in construction to the flow meter, except there is no electromagnet, and current is then proportional to pressure.)

**Electrohydraulic actuator**—is the power unit used throughout the system. It is fully self-contained, complete with oil tank, motor, pump, and control cylinder. The heart of the actuator is the familiar jet-pipe regulator (Ref. 1) with a receiver for the 0-to-25 vdc signal from transmitters. The electrohydraulic actuator eliminates hydraulic piping; only wires for signal leads and power to the pump motor are needed at the installation. The system uses several actuator sizes, all identical in principle but differing in available output power.

**Set-point Adjusting Station**—positions actuator stem to give desired value of temperature, flow, pressure, heat input, etc. It is a simple unit without amplifier. A five-position switch—open, neutral, automatic, neutral, close—provides manual and automatic control. On automatic, 25 vdc from a power supply is reduced by a set-point potentiometer to a value representing the desired control point. This voltage is compared with the transmitter signal; any difference moves the actuator's control cylinder in the direction to return the difference to zero. On close, full 25 volts of one polarity positions the control cylinder to close the valve. On open, polarity is reversed, fully opening the valve. On neutral, a solenoid operates the actuator's shutoff valve, locking the control cylinder in its last position.

**Ratio Adjusting Station**—changes the proportion of two or more flows. It is a simple unit, without amplifier for two flows, with power amplifier for more than two flows. It is similar to the set-point adjusting station, except that signals from the transmitters (of flows to be ratioed) are modified, one by a fixed voltage divider, the other by a ratio potentiometer. The modified voltages are compared; if any difference exists the resulting signal positions the valve to restore the desired ratio. The ratio pot has a scale calibrated 0.5 to 1.5. When the ratio adjusting station proportions more than one flow on either or both sides, scaling resistors bring the signals to a common denominator. An amplifier is used when power is dissipated in the scaling resistors because of an unfavorable scaling ratio. A selector switch provides the open, neutral, automatic, neutral, close control as in the set-point adjuster.

**Three-Term Controller**—is used instead of the set-point station where the controlled process has an inherent time lag or creates unstable conditions. The controller has adjustable proportional, reset, and rate actions. Its output operates a positioning type electrohydraulic actuator. The basic parts of the controller are: set-point adjuster; amplifier; measured-variable, set-point, and valve-position indicators; manual/automatic selector and position set-point adjuster; and response control (reset and rate action). Amplifier output when used with actuator is 1-to-5 ma dc; when connected to summarizing circuit, output is converted to desired voltage by scaling resistors.

**Indicators**—are d'Arsonval dc voltmeters, with 7- or

14-in. calibrated scales. Zero adjustment on each meter.

**Recorders**—are two-pen, strip chart units with 0-to-25 vdc input. Scale is linear, 4 in. wide. Recorders are force-balance type, with simple amplifier for each pen. Incoming signal displaces balance beam, upsets oscillator which causes amplifier to vary its output to a rotary solenoid. Solenoid operates pen and feeds back to balance beam.

**Control Panel**—is totally enclosed, completely wired to terminals. Instruments, set-point stations, and switches are arranged for easy operation and complete process supervision. Three pilot lights and 14-in. indicators give temperature indications. Seven-in. indicators are used for other variables. The panel has three two-

pen recorders, one for waste heat boiler inlet and outlet draft; the others (total of four pens) record other variables to indicate furnace trends. Each pen has a six-position selector switch, each position corresponding to a different variable. Thus, any four furnace variables can be recorded at the same time.

Also on the panel front are process set-point adjusting stations and remote manual switches for reversing valves. Computer input switches, pushbuttons, and indicating lights, used by the operator, also provide the computer with information related to furnace operation. Two clocks are furnished, one indicates time of day, the other, reset to 12:00 at every tap, indicates heat elapsed time.

## USING DIGITAL COMPUTER-LOGGER ON OPEN-HEARTH FURNACES

The main objectives of the LIBRATROL-500 computer system are to increase open-hearth efficiency and yield. To accomplish this, the computer performs two separate, but related, functions. It:

- scans, computes, and logs furnace data, and
- provides scheduling guides to operators

Studies of open-hearth shops show that these functions would shorten heat time, increase furnace life, improve product quality and consistency, and reduce accounting and fuel costs.

Figure 3 shows the computer (in the superintendent's office) and connections between it and the operator's station and control system on the furnace floor. The computer, a general-purpose machine, has a magnetic-drum memory which stores input data from furnaces and operators, programs for processing the inputs, and heat schedules for different steels. The programs contain the detailed logical procedure, determined by analysis of the open-hearth shop, to carry out furnace operation in an efficient manner.

The computer-logger control system is a combination of selected equipment providing compatibility of signals. A voltage-to-digital converter assures compatibility between the 0-to-10 vdc analog signals from the automatic control system (reduced from 0-to-25 volts by a voltage divider) and the computer's digital inputs. Other inputs to the computer are in the form of presence or absence of signals; these binary-coded signals are inherently compatible with the computer. Another example of equipment compatibility is that computer command-signals synchronize the speed at which computer outputs are logged on printers. A brief description of the LIBRATROL-500 is given in Table I.

### Computer inputs

The computer receives inputs from furnaces and from operators, Figure 3. In general, furnace inputs are associated with the computer's data processing function, and those from operators with the computer's scheduled-operations function. The

furnace inputs are from transmitters also used in the control loops. The operator inputs are from transmitters located on the control panel on the furnace floor:

► **heat program transmitter**—a six-position switch, each position producing a dc voltage which, after digital coding, selects a predetermined schedule of time intervals stored on the drum.

► **heat cycle transmitter**—a six-position switch for manually advancing a selected heat program from off through *makeup, charge, hot metal, melt, and tap* sequence, Table II

► **delay transmitter**—an eight-position switch that codes for identification eight furnace delays which may occur during the heat program if the operator does not complete a heat-program cycle in the allotted time stored on the drum

### Computer outputs

The computer system has three output modes:

► **printers**—seven Monroe Model 203 printers are supplied; six log data from 12 furnaces; the seventh logs special test data and daily fuel totals

► **furnace-and-printer selector**—a matrix of 16 mercury-wetted relays selecting 16 groups of inputs: 12

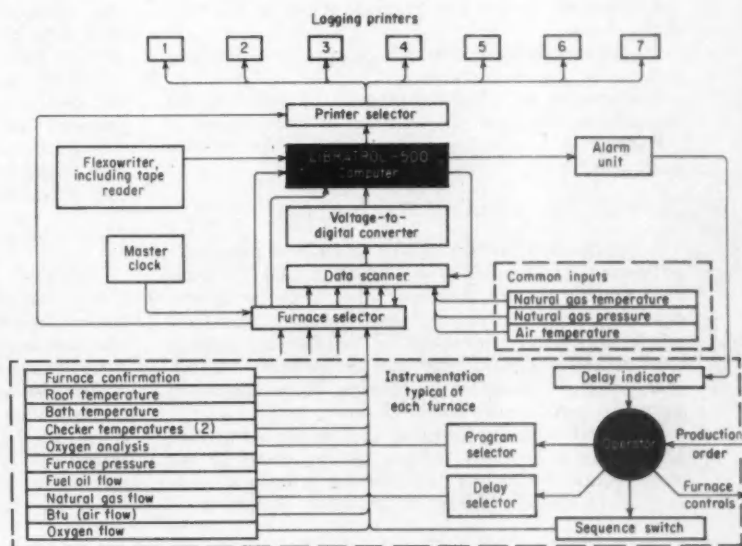


FIG. 3. LIBRATROL-500 system for open-hearth furnace monitoring.

Table I LIBRATROL-500 Digital Computer

Manufacturer:	Librascope, Inc.
Distributor:	GPE Controls, Inc.
Computer type:	general-purpose digital
Number base:	binary
Mode of operation:	serial
Instruction type:	single address
Number of different instructions:	16
Memory:	magnetic drum
Memory capacity:	4,096 words
Word length:	30 binary bits plus sign
Input switching:	integral to system
Input switching speed:	200 per sec max
Input switching capacity:	expandable design — to fit system requirements (maximum 1,024)
Voltage-to-digital converter:	Internal, 1 millisecon conversion time
Input Sequencing:	by computer command
Input voltage range:	0-10 vdc
Voltage conversion accuracy:	± 0.1 percent of full scale
Output channel capacity:	expandable — to fit system requirements

Table II HEAT SEQUENCES

MAKEUP — period between heats for furnace repairs
CHARGE — Initial filling of furnace with raw materials
HOT METAL — period in which molten pig iron from blast furnace is added
MELT — period of refining steel to desired characteristics
TAP — removing finished steel to ladles

relays for the 12 furnaces; one each for daily-totals, special-test, and computer-maintenance programs; and one for a digital clock. Six contacts on each relay code the addresses for the furnaces and program and select

## GENERAL SYSTEM OPERATION

To produce steel from the open-hearth furnace, the furnace operator (melter) receives a written production order for a specific type of steel, its heat program, and the settings for furnaces control during the heat program. Referring to Figure 3, the operator then:

- sets the furnace controls
- selects the proper heat program stored in the computer memory
- informs the computer which sequence the heat program is in at the moment
- adheres to the scheduled program by observing the elapsed-time clock and the warnings of delay alarms
- identifies any delays by positioning the furnace delay selector

### Normal data scanning and logging

A digital clock in the LIBRATROL-500 provides a pulse every 0.01 hours (36 sec) which initiates the scanning period. Within this time, the computer selects, digitizes, scales, applies zero offset, linearizes, performs simple arithmetic, and stores on the memory drum a total of 216 points—12 furnaces each having 18 variables. The programs for performing these operations are stored permanently on the drum.

The total time for scanning and storing data from 12 furnaces is less than 15 sec, leaving about 21 sec of the period for logging decisions and printing average furnace conditions. When 20 scanning periods have

their associated printers. In the locked position, the scanner is under control of the digital clock, but when the scanner is reset to No. 1 furnace, it is controlled by the computer to sequentially select the 16 groups of input data. A signal from each selector relay energizes a corresponding furnace line relay which connects the variables to be measured to the telemetering lines to the computer

► **alarms**—five relays, momentarily operated by computer output logic, indicate furnace delay and furnace reversal and direct the highest-reading roof temperature probe (of three probes, selected by the computer) to the total fuel/combustion-air ratio and waste-gas oxygen content control system

### Computer accessories

Several accessories are required for complete compatibility with transducers from the control system, for selecting inputs and for writing programs on the drum:

► **voltage-to-digital converter**—is of the successive approximation type. Voltage range is 0 to 10 vdc. Its digitizing time is 1 millisecon. Digitizing is under computer command

► **data scanner**—is a matrix of mercury-wetted relays providing 64 channels. It sequentially scans the telemetered variables of the furnace selected by the furnace-and-printer selector

► **Flexowriter**—an electric typewriter with a paper-tape punch and reader, is the computer's means of accepting manual inputs. A computer operator types out the program on the keyboard which simultaneously punches a tape. Run through the reader, the tape inserts programs into the computer memory

been completed the computer transfers to the averaging and printing program. That is, the computer adds the 20 readings for each variable, divides the total by 20, and prints out the average value. Table III lists information for each furnace logged on the printer.

In addition, the computer corrects the average flow rate values of natural gas, steam, metallurgical oxygen, coke oven gas, and air. The computer also totalizes fuel flow by multiplying average flow rates by elapsed time (since the previous average computation) and adding the product to totals stored in the computer from previous calculations.

Normal scanning and logging continues for the duration of the heat unless interrupted by another program, one of which is heat cycle logging.

### Heat cycle logging

Totals of all measured flows are desired at the completion of each sequence in the heat program so that a cost analysis of *makeup, charge, hot metals, melt, and tap* sequences can be made. Initiation of heat cycle logging is accomplished manually or automatically. When the operator completes a sequence before the allotted time-interval stored in the computer, he advances the heat-cycle switch to the next sequence. The logged data is shown in Table IV. On completing the printing of this information, the computer begins monitoring the elapsed time of the next scheduled sequence

Table III NORMAL DATA LOGGING

Time of day	hours and 0.01 hrs
Elapsed time of heat	hours and 0.01 hrs
Furnace identification	number
Heat program selected	code number
Waste gas oxygen	percent
Furnace pressure	inches of water
Roof temperature	deg F
Bath temperature	deg F
Air checker temp.	deg F
Combustion checker temp.	deg F
Checker temp. difference	deg F
Fuel oil flow rate	gph
Natural gas (or steam) flow rate	Kilo cfm
Air (btu) oxygen flow rate	Mega btuh
Metallurgical oxygen flow rate	Kilo cfm
Coke oven gas flow rate	Kilo cfm

Table IV HEAT CYCLE LOGGING

Time of day	Fuel oil totals
Elapsed time from start of heat	Natural gas (or steam) totals
Furnace identification	Air (btu) totals
Heat program	Metallurgical oxygen totals
Sequence the heat is in	Coke oven gas totals

and continues normal data scanning and logging.

However, when the allotted time for performing a sequence is exceeded, the computer automatically recognizes this delay, completes the normal scanning underway, and transfers to the delay program. Totals are logged in black. In addition, the computer energizes an alarm which turns on a red warning light and which causes subsequent normal logging to be printed in red until the sequence is completed by the operator and he advances the sequence switch to the next position. Then the (new) heat cycle total is printed out in red, along with an identifying delay code number. Completion of printout resets the delay alarm and initiates normal scanning and logging for the next sequence.

The computer also logs daily fuel totals required by the accounting department for cost analysis and billings. Since the computer is calculating totals for various heats, it is a simple task for the computer to add the heat totals and store them in additional memory locations for daily totals. The computer continuously compares the time of day (from the digital clock) to the desired logging time for daily totals; when the two are equal (say at 23.99 hr), the computer prints out accumulated totals for fuel oil, natural gas (or steam), metallurgical oxygen, and coke oven gas. A number of

memory channels and scanning points are also provided for special test programs.

### Computer programs

Throughout the description of the computer's data processing and scheduled-operations functions reference has been made to various computer programs. A program is a collection of instructions and data recorded in the computer memory. System behavior and process operation are determined by the sequence of instructions. The computer reads the signal transmitters from furnaces in any sequence and at the time called for by the programs.

The problem of programming is one of defining the open-hearth process and then deciding the sequence of tasks the computer is to perform in meeting process requirements. The technique of block diagrams, or English programming, allows a person to define what the system is to accomplish even though he is not trained in computer programming. A skilled computer programmer later converts these English instructions to machine language.

Each block is a short series of instructions in the computer program. These instructions accomplish the job specified in the block. The job may be to make certain calculations or to make a decision based on some number in the memory. A block which is simple and does not involve a decision has one arrow entering and one leaving. This program is never altered in operation. A block which includes a decision has one arrow entering and two arrows leaving, one for a yes

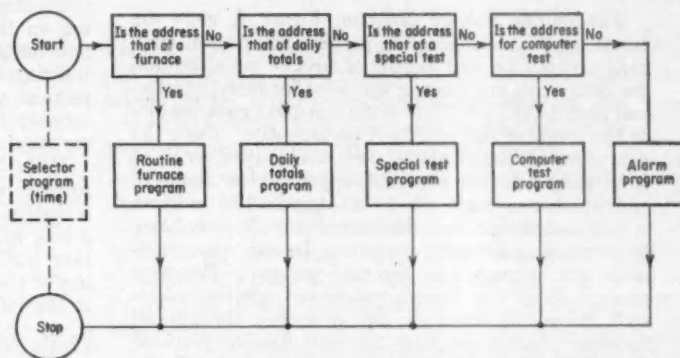


FIG. 4. General computer program.

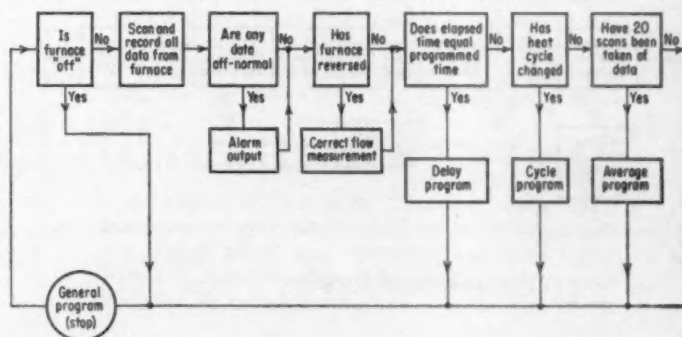


FIG. 5. Routine furnace program.

decision and one for no. The computer can only decide yes or no, so questions in decision-making must be phrased such that they can be answered yes or no. The computer performs different operations depending on either the yes or no decision.

The computer can also alter addresses in instructions and thus alter the total sequence of events according to decisions made while monitoring the process. An address tells the computer where to go in the memory for the next instruction. It is the decision-making ability of the computer to modify its own program that makes it an extremely powerful and flexible tool.

Most system programs are stored in the computer's drum memory, but one program—that for the furnace-and-printer selector—is external to the computer, as shown in the total system diagram, Figure 4. Its basic operation has been described under computer outputs; its block diagram is not shown.

The general computer program, Figure 4, analyzes the first data input, the address of the selected furnace. By comparing the input address to a library of addresses in the memory, the computer decides which other programs or instructions to follow. The logic of the general program is determined by the order or priority of decisions. Data from furnaces and processing of this data is of prime importance. These routine furnace programs are given first priority, as shown in the block diagram. Daily totals are required once a day and are given second priority. Special tests and computer test programs are given lesser priority, with computer-failure alarm given lowest priority.

### Routine furnace program

The routine furnace program, Figure 5, gives the computer the intelligence to perform the normal scanning, computing, and logging of furnace variables, and the computing and logging decisions for delay, average, and heat cycles. The logic of this program gives priority to the scanning and storing of furnace data. Once the data is stored, the computer must decide whether there is a delay, whether the heat sequence has changed, and whether averages are to be logged. The program is so arranged that a yes decision on any decision block by-passes all succeeding programs. In this way, minimum time is needed for the total program. The computer, through the furnace-and-printer selector, selects each furnace in sequence and progresses through all necessary routine programs for each furnace provided the selected furnace is on. If the furnace is off, the routine program senses it and by-passes that furnace.

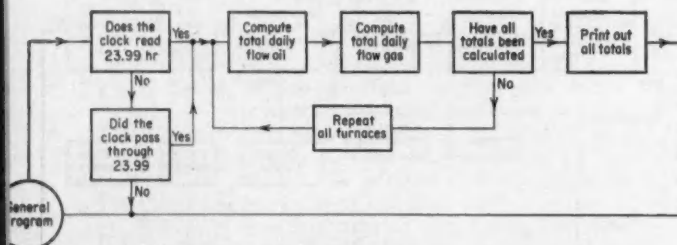


FIG. 7. Daily accounting totals program.

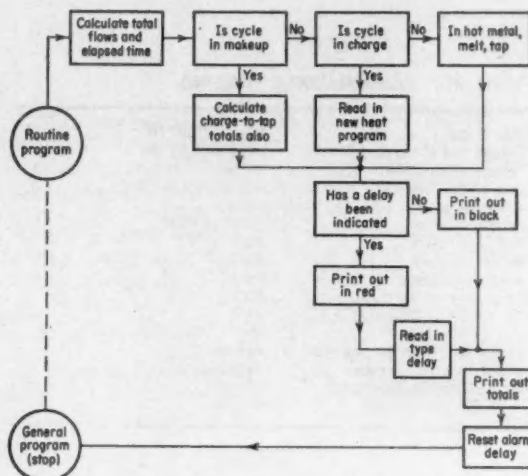


FIG. 6. Heat cycle program.

### Heat cycle program

The heat cycle program, Figure 6, is one of the routine furnace programs. It provides the necessary calculations and decisions to log out totals for a given heat cycle. As an example, suppose a furnace is in the tap sequence. Near the end of this sequence, the operator advances the sequence selector to makeup. During normal scanning the computer senses this change and transfers to the heat cycle program at completion of the current scan period. As shown in the block diagram, a number of decisions are made depending on the status of the heat. Since the computer now reads the cycle as *makeup*, the change in sequence indicates the end of a tap and, therefore, the completion of a heat. The program therefore takes into account that *tap-to-tap* totals and *charge-to-tap* totals are required.

If the heat is between *makeup* and *charge*, then the furnace repairs have been completed and a new heat is started. Assuming a different steel is to be made, a new heat program is necessary. The operator positions the heat selector switch to the position corresponding to the new heat program, and the computer reads in this information between *makeup* and *charge*.

### Daily totals program

Once a day, say at 23.99 hours, the daily fuel flow totals are required for accounting purposes. When this time arrives the computer sees the address calling for daily totals program, as shown in the general program, Figure 7. On completion, the computer resumes routine operation, scanning and logging data and pacing the operator as he performs his duties.

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# Fundamentals of Multivibrators—II

This two-part study of selected multivibrators especially suited for control systems continues with several high-speed transistor circuits featuring the use of steering and breakdown diodes. Also described are the monostable and astable versions of transistor multivibrators plus a group of novel circuits incorporating unijunction transistors, square-loop magnetic cores, and cryotrons to provide multivibrator action.

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The first part of this article (Control Engineering, June 1959) concluded with a discussion of the possibilities for enhancing the switching characteristics of transistor multivibrators. Specific mention was made of two means for achieving higher transfer speeds: one involves an increase in the base drive current and the second, the addition of clamping diodes. Still another approach to this end is through special circuitry for directing the input trigger straight to the nonconducting transistor. This technique speeds the switching process and reduces the power required of the input trigger.

Figure 1 shows a circuit suitable for this type of action. In essence, it is a conventional transistor multivibrator to which diodes  $D_T$ ,  $D_G$ , and  $D_{G1}$  and capacitor  $C_T$  have been added. When  $T_1$  is conducting and  $T_2$  is cut off, the application of a negative trigger pulse at point  $T$  causes diode  $D_{G1}$  to conduct before  $D_G$ . The current through  $D_{G1}$  must flow also through  $R_{L2}$  (since  $T_2$  is cut off), setting up a negative swing of the  $T_2$  collector voltage that drives  $T_1$  toward cutoff. The ensuing positive voltage transient at the collector of  $T_1$  forces  $T_2$  into conduction so that the multivibrator completes its transition. The next negative trigger initiates transfer back to the original conditions of operation,

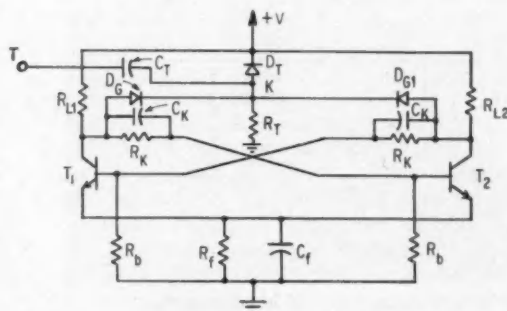


FIG. 1. High-speed transistor multivibrator uses diodes for directing trigger signals.

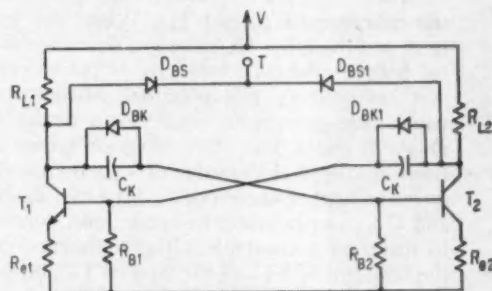


FIG. 2. Breakdown diodes provide clamping of transistors and speeds transition.

because now  $D_G$  starts conducting before  $D_{G1}$ . It can be seen that this arrangement always routes the trigger pulse through the conducting diode to the cut-off transistor only; the nonconducting diode blocks the trigger from the conducting transistor.

It is preferable to connect the steering diodes to the collectors rather than to the bases because the collector voltage differential is much larger than the base-voltage differential. Diode  $D_T$  clamps point  $K$  to collector voltage  $V$  and prevents the build-up of an excessive charge across capacitor  $C_T$  that would tend to reduce the trigger voltage. The clamping diode may be replaced by a discharging resistor between point  $K$  and ground, provided the time constant of the combination of this resistor and capacitor  $C_T$  is much smaller than the minimum pulse repetition rate. It is also possible to trigger the circuit of Figure 1 with positive pulses. In this case,  $D_G$  and  $D_{G1}$  are reversed in polarity and  $D_T$  connected between  $K$  and ground. With this variation, the off transistor is driven into conduction instead of the on transistor into cut off.

## Use of breakdown diodes

As explained previously, clamping diodes offer one means of preventing transistor saturation, reducing storage effect, and increasing switching speed. Figure 2 shows another arrangement that provides a clamp for transistors but avoids saturation of the

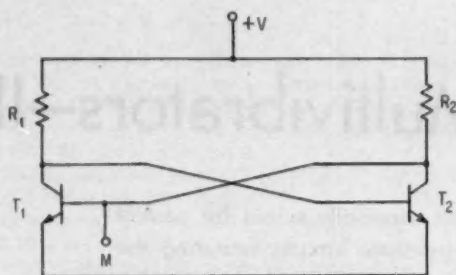


FIG. 3. Direct-coupled transistor multivibrator uses minimum of components.

clamping diodes (Ref. 8). In this circuit, diodes  $D_{BS}$  and  $D_{BS1}$  are connected back-to-back between the collectors of  $T_1$  and  $T_2$ . When one transistor is on and the other off, there is a difference of potential between the collectors. By proper choice of circuit components, this potential difference can be made large enough to break down diodes  $D_{BS}$  or  $D_{BS1}$ . If this is done, the voltage difference is effectively regulated at the value of  $V_{BS}$ , the rated breakdown voltage of the diodes. Similarly, diodes  $D_{BK}$  and  $D_{BK1}$  can be made to break down continuously to maintain a constant voltage difference between the collector of  $T_1$  and the base of  $T_2$ , and between the collector of  $T_2$  and the base of  $T_1$ . As a result of this arrangement, diodes  $D_{BS}$  and  $D_{BS1}$  clamp the collector potentials of  $T_1$  and  $T_2$ , while the reference potentials established by  $D_{BK}$  and  $D_{BK1}$  fix the stable points of circuit operation. In addition to clamping, diodes  $D_{BS}$  and  $D_{BS1}$  serve also as steering diodes operating from a positive trigger.

The operation of the circuit is as follows: when  $T_1$  is conducting,  $D_{BS}$  is broken down and is passing current in the reverse direction. At the same time,  $D_{BS1}$  conducts in the forward direction. When a positive trigger is applied, the conductivity of  $D_{BS}$  increases while the conductivity of  $D_{BS1}$  decreases to cut off. Simultaneously, the base potential of  $T_2$  rises as a result of the increasing current through  $D_{BS}$ . During the subsequent transient, the collector voltage of  $T_2$  decreases and that of  $T_1$  increases. Both  $D_{BS}$  and  $D_{BS1}$  assume the status of open circuits, isolating the trigger source from the multivibrator. The transient terminates with the breakdown of  $D_{BS1}$ , which acts through  $D_{BS}$  (conducting forward) and  $D_{BK}$  (in continuous breakdown) to prevent saturation of  $T_2$ . The magnitude of the trigger pulse must remain below a certain maximum to avoid the breakdown of  $D_{BS1}$  before  $D_{BS}$  reaches the open-circuit condition. Should this be allowed to happen, trigger current would reach both bases, causing switching to become erratic.

Although the transistor switching time is short in this configuration, the maximum repetition rate attainable is still much less than the cut-off frequency  $f_{co}$  of the transistors. Thus, a transistor having an  $f_{co}$  of 10 mc and an  $\alpha_{BO}$  of 0.98 may be expected to have a maximum permissible funda-

mental frequency on the order of 1.4 mc and a pulse driving rate of 2.8 mc in bistable applications.

### Direct-coupled multivibrators

If the collector-to-emitter saturation voltage of a transistor is less than the base-to-emitter drop, it is possible to build a multivibrator using only four components: two transistors and two resistors. Such a circuit is shown in Figure 3. If  $T_1$  is saturated, the base of  $T_2$  is at a potential low enough to prevent  $T_2$  from conducting, while the current through  $R_2$  is sufficient to hold  $T_1$  on. In this operation the collector voltage swing is small, equaling the difference between the collector-to-emitter saturation potential and the base-to-emitter voltage. However, the collector current transient between the cut-off and saturation states can be quite large. As in most multivibrators, switching speed is determined primarily by the properties of the transistors selected.

The main advantage of direct-coupled multivibrators is the economical use of components. In addition, the circuit is well suited for the simple direct-coupled transistor logic found in computer applications. The disadvantages of this form of multivibrator are that the output voltage swings are limited and that the base of the nonconducting transistor has no negative bias relative to its emitter. The off transistor does not conduct simply because its base is not at a sufficiently positive voltage. This

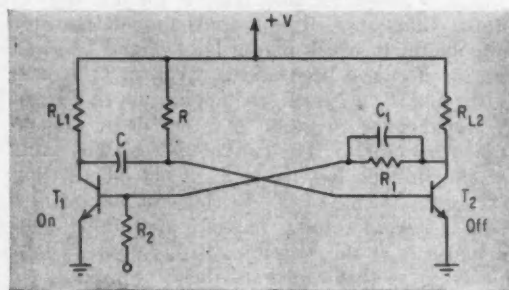


FIG. 4. Monostable transistor multivibrator is derived from bistable type by unbalancing the components.

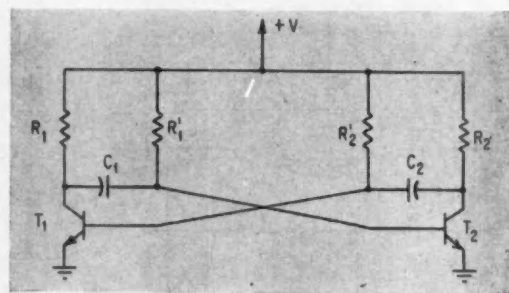


FIG. 5. Astable circuit is obtained by adjusting the bias voltages in a monostable circuit.

absence of reverse cutoff may result in spurious triggering by random currents. Because of the relatively higher forward voltage drop between emitter and base, silicon transistors are more reliable in this respect than the germanium types.

### Monostable and astable multivibrators

Monostable multivibrators are formed of circuits that have one stable state. The circuit transfers with the application of an input signal, but returns to its original state after a length of time depending on circuit constants. This type of operation is useful in applications such as fixed or variable delay pulse generators and pulse shapers. Any conventional bistable multivibrator can be converted to the monostable mode by unbalancing the circuit. In the simple monostable multivibrator of Figure 4, the component values are chosen so that  $T_1$  is off and  $T_2$  on in the absence of external signals. A negative pulse applied to the collector of  $T_1$  is transmitted to the base of  $T_2$ . As  $T_2$  goes into cut off, its collector potential rises and switches  $T_1$  to the conducting mode. The circuit does not remain in this state indefinitely, however, because the base voltage of  $T_2$  rises exponentially as  $C$  charges through  $R$ . Transistor  $T_2$  starts to conduct, initiating feedback that restores the circuit to its original condition.

The bias of a multivibrator can be adjusted so that neither of the transistors remains in the stable state. Under this condition, the multivibrator becomes astable or free-running. Figure 5 shows such a multivibrator; its operation is closely analogous to that of the monostable circuit described above.

### OTHER TYPES OF MULTIVIBRATORS

The previous sections discussed multivibrator circuitry comprising conventional transistors and tubes. While these components do dominate the multivibrator field, successful use has also been made of other basic components, such as the unijunction diode, the square-loop magnetic core, and the cryotron. The concluding part of this article will be devoted to selected circuits based on components other than tubes and conventional transistors.

#### Unijunction transistor

The unijunction transistor or "double-base diode" is a comparatively new semiconductor device that is of interest in multivibrator design (Ref. 9 & 10). The unijunction transistor has one p-n junction and two ohmic contacts. The device has a negative resistance characteristic, which can be used to obtain the multivibrator operation.

Figure 6 shows a multivibrator that consists of unijunction transistor  $UT$ , diode  $D$ , capacitor  $C$ , and resistors  $R_1$ ,  $R_2$  and  $R_3$ . The operation of the circuit is as follows: when positive supply voltage  $V$  is applied, capacitor  $C$  charges through  $R_2$  and diode  $D$ . During the charging cycle of the capacitor,  $D$  is conducting but the unijunction transistor is

cut off. When the potential across the capacitor becomes equal to or greater than the peak-point potential of the unijunction transistor, the latter becomes unstable and switches into the conducting stage. The junction potential  $V_2$  is then clamped almost to ground potential, causing  $D$  to cut off. Then capacitor  $C$  discharges through  $R_1$  until potential  $V_1$  is approximately equal to the junction potential  $V_2$  of the unijunction transistor. At this point, the diode conducts again, the current through the transistor junction decreases, and the unijunction transistor is driven into cut off. Capacitor  $C$  recharges and the cycle is repeated indefinitely. Since capacitor  $C$  alternately charges and discharges through  $R_2$  and  $R_1$ , voltage  $V_1$  consists of a periodic exponential rise and decay.

When the unijunction transistor is cut off, the

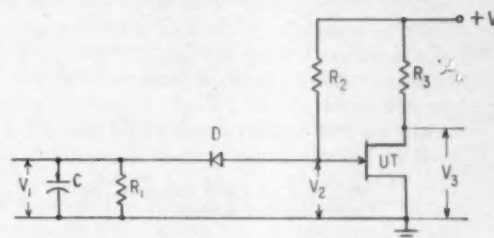


FIG. 6. Sample multivibrator circuit makes use of one unijunction transistor.

current through  $R_3$  is comparatively low. When the transistor fires, however, the current through  $R_3$  increases. Thus, the current through  $R_3$  is either high or low, depending upon the operating state of the unijunction transistor. The output voltage  $V_3$  is a square wave whose frequency and degree of symmetry depend on the time constants associated with resistors  $R_1$  and  $R_2$  and capacitor  $C$ .

The design criteria for astable operation of the multivibrator are as follows:

$$\frac{R_1 V}{R_1 + R_2} > V_P \text{ and } \frac{V}{R_2} \leq I_V$$

where  $V_P$  is the peak-point potential of the unijunction transistor and  $I_V$  is the input current corresponding to its valley point. The values of  $V_P$  and  $I_V$  are determined from the performance characteristic of the device. The multivibrator can be made monostable under the following conditions:

$$\frac{R_1 V}{(R_1 + R_2)} < V_P \text{ and } \frac{V}{R_2} < I_V$$

If these requirements are met, a positive pulse will trigger the unijunction transistor from off to on. The transistor conducts until capacitor  $C$  discharges through resistor  $R_1$ . When the diode reverses at

the end of the capacitor discharge cycle, the transistor cuts out and the multivibrator remains stable until the next positive trigger pulse appears. The main advantage of using the unijunction-transistor in multivibrator circuitry is that the number of components required is about half that needed in conventional transistor configurations.

### Square-loop magnetic core

The so-called square-loop magnetic materials have a  $B$ - $H$  characteristic similar to that shown in Figure 7. Square-loop cores may be formed of ceramic ferrite material or of an extremely thin ferromagnetic alloy tape wound on a non-magnetic spool. If a positive magnetizing force  $H$  is applied to the core and then removed, a certain amount of flux remains. The residual flux, plus  $\phi_r$  or minus  $\phi_r$ , establishes the two stable states (1 and 0) of the core. Because the core remains in either one of the two stable states without consuming power, it offers interesting

possibilities for use as a memory element.

Figure 8 shows a single core that performs essentially the same function as a bistable flip-flop. A current pulse of plus or minus  $I_1$  applied to winding  $N_1$  establishes a residual flux of plus or minus  $\phi_r$ . A sampling pulse  $I_2$  applied to winding  $N_2$  serves to reset the core to minus  $\phi_r$ . An output pulse appears at winding  $N_3$  only if  $I_1$  has previously established a residual flux of plus  $\phi_r$ . Thus, the presence of an output pulse indicates that the state of the core has been switched from plus  $\phi_r$  to minus  $\phi_r$ , or from a 1 to a 0. A characteristic of the square-loop core is that its switching time is inversely proportional to the voltage applied to the core.

An interesting example of the use of square-loop cores is the astable multivibrator of Figure 9. The circuit is essentially a standard Eccles-Jordan flip-flop, except that the usual collector resistors have been replaced with windings on a square-loop core. The conducting transistor develops a collector volt-

FIG. 7. Typical  $B$ - $H$  relationships for square-loop core material.

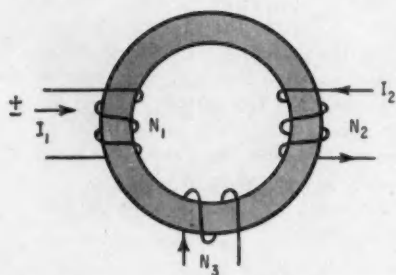
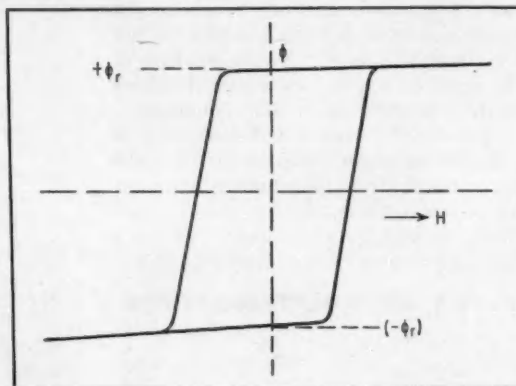
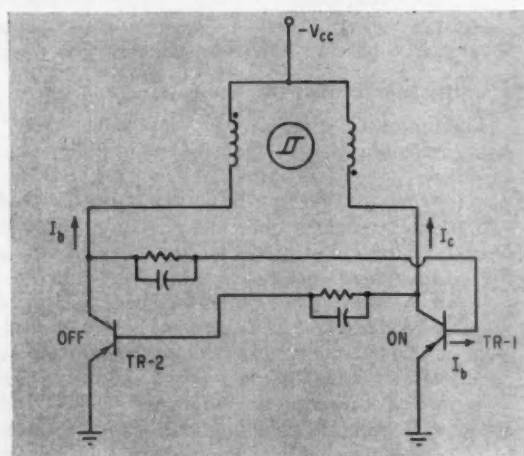


FIG. 8. Simple magnetic-core element is capable of performing as bistable flip-flop.

FIG. 9. Astable multivibrator circuit uses square-loop cores to get free-running action.



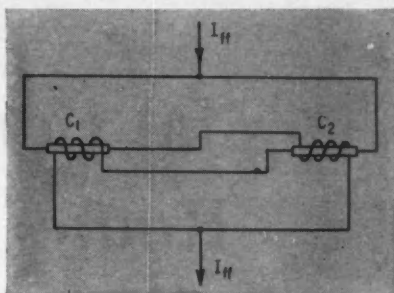


FIG. 10. Basic cryotron flip-flop has cross-coupled gates and control coils.

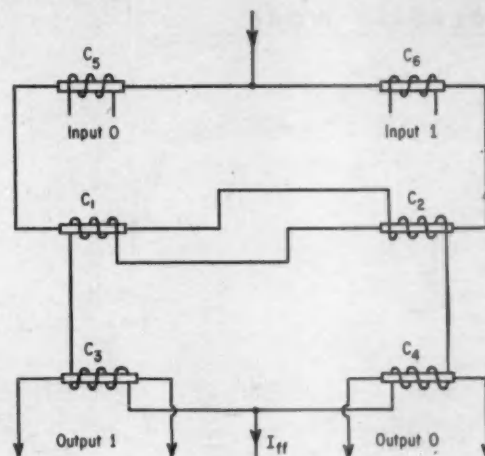


FIG. 11. Complete bistable cryotron multivibrator has input and output cryotrons as well as cryotron binary.

age that is sufficient to hold the other transistor cut off while the core is switching to, say, plus  $\phi_r$ . When the core has switched, the collector voltage swings in the negative direction. This swing is applied to the opposite base and is sufficient to trigger the other transistor into conduction. The second transistor then saturates the core in the direction of minus  $\phi_r$ , and thus once again develops a collector voltage that will hold off the first transistor. The period of oscillation is a function of the magnitude of minus  $V_{cc}$  and is approximately twice the time required for the square-loop core to switch (neglecting transistor switch-over time). This type of circuit can be used as an oscillator with an output frequency that varies linearly with the applied voltage ( $-V_{cc}$ ).

## Cryotron

The cryotron is a relatively new switching component whose operation is based on the superconductivity phenomenon observed in conducting material subjected to extremely low temperatures. Switching action is achieved by the application of a controlled magnetic field that negates this superconductivity. The presently used cryotron configuration is a 9-mil tantalum wire (called the gate) around which is wound a 3-mil niobium wire that serves as the control coil. When the cryotron is immersed in liquid helium, the resistances of both control coil and gate approach zero and they become superconductive.

The ability to change the resistance of the tantalum wire by means of a magnetic field makes possible numerous types of digital switching circuits. One of these is the basic bistable multivibrator, Figure 10, which consists of cross-coupled cryotrons  $C_1$  and  $C_2$ . A current  $I_H$  flows through one of the two gates. Because the gate of one cryotron is connected in series with the control field of the other, the circuit is inherently bistable; a current established in one path automatically cuts off the other.

Figure 11 shows a complete bistable multivibrator having input cryotrons  $C_5$  and  $C_6$  to provide a means for switching the flip-flop, and output cryotrons  $C_3$  and  $C_4$  to furnish a signal to other cryotron circuits. The supply current  $I_H$  is directed to the gates of cryotrons  $C_2$  and  $C_1$  by the action of steering cryotrons  $C_5$  and  $C_6$ . A current signal applied to the control coil of either  $C_5$  or  $C_6$  causes  $I_H$  to be shunted through the gate of the alternate cryotron. Cryotrons  $C_3$  and  $C_4$  deliver the output signals that reflect the state of the flip-flop. If, for example, there is current in the control coil of  $C_3$ , a relatively high resistance appears at its gate terminals. At the same time, the absence of current in the control coil of  $C_4$  allows the resistance across its gate terminals to remain near zero.

The cryotron may play a significant role in future computer design. It is extremely small and inexpensive and, from the investigations to date, appears highly reliable. These factors could easily offset the disadvantage imposed by the need for a constant supply of liquid helium.

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# Digital Codes Route Interoffice Mail

Magnetic tabs attached to tote-box carriages on mail conveyor are addressed to deliver boxes to correct destinations. A typical vertical conveyor for large office buildings is described.

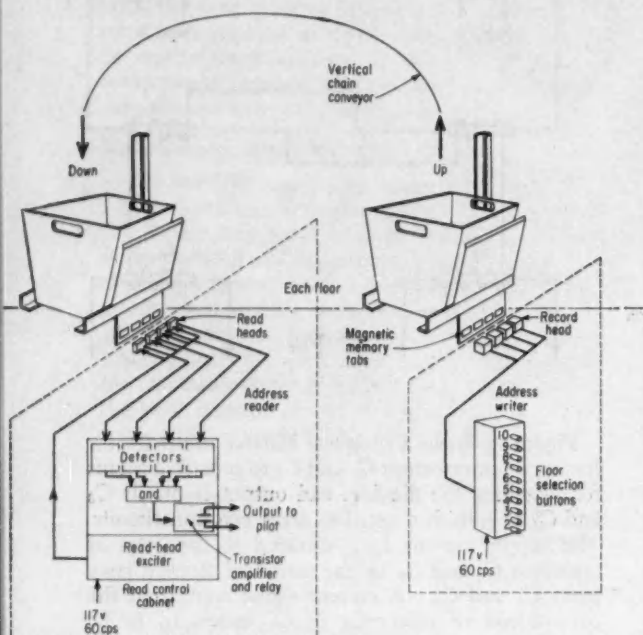


FIG. 1. In automatic record lift system, magnetic tabs are code-addressed on up-going side at loading stations, actuate correct unloading mechanism automatically on down-going side

C. M. ZOUBEK, Standard Conveyor Co.

The automatic vertical conveyor in Figure 1 is used by large office buildings, insurance offices, or hospitals where a large volume of interoffice mail and correspondence must be distributed. The conveyor consists of a number of carriages attached to an endless vertical chain. Automatic stations load trays or tote boxes onto carriages on the up-going side of the lift, and automatic unloading stations unload from the down-going side.

A typical system can dispatch from any station and receive at any other station. Such a system can also be laid out in a horizontal position and used for other interoffice functions, warehousing, or distribution.

The Record Lift conveyor is operated by two interlocked control systems. A third, or monitoring system, can be added. The first control system is a safety circuit which determines when load and unload stations may operate, and protects the lift against damage from interferences, or overloads. These safety controls involve no novel feature.

The second control system is a

unique application of magnetic recording and reading. It controls the final destination of the mail-containing tray or tote box by means of small magnetic tabs attached to either the carriages or the tote boxes, Figure 2. The destination address is recorded magnetically in binary code on the

FIG. 2. Tabs may be connected to conveyor carriage as shown, or directly to tote boxes. Note that magnetic heads do not contact tabs.



tabs at the time the tote box is loaded into the system.

If the tabs are attached to a lift carriage, the previous code must be erased with an ac field after the carriage is unloaded and before it starts its next upgoing cycle. This will prevent the conveyor being stopped by an empty carriage on the next cycle. If the tabs are attached to the tote boxes, this erasure is unnecessary. Recording a new code completely obliterates any previous code, since the recording signal saturates the tabs.

Each loading station has a set of recording heads, one for each tab, which record an N-S or a S-N polarization in the correct tab sequence according to the interwiring of the address-writer pushbuttons.

Each unloading station has a set of magnetic reading heads so wired that only a correctly-coded set of tabs will produce a positive output signal. Only if the output signal from the read head array is positive will the transistor amplifier conduct and pull in a pilot relay. This pilot relay will then actuate the unloading station.



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**NUMBER:** 8, expandable to 512 with additional optional plug-in components.

**SEQUENCE:** By computer command; changeable by program.

**VOLTAGE RANGE:** 0-1 and 0-10 (or more) volts d.c.

**MANUAL:** Flexowriter and punched paper tape.

**DIGITAL CLOCK:** Internal, pure binary, real time to provide time of day for logging.

#### OUTPUTS

Flexowriter and punched paper tape; and computer logic producing 10-bit addressable word to actuate relays for control signals.

**SPEED AND NUMBER:** 66 outputs per second; time-sharing permits unlimited number.

**SEQUENCE:** By computer command; changeable by program.

**TIME READOUT:** From digital clock.

**TYPICAL OPTIONAL CONTROL FUNCTIONS AVAILABLE:** Alarms, voltage level, bridge balance, relay closure, setpoint, reset rate, proportional band, variable time delay, recorder, plotter.

#### GENERAL SPECIFICATIONS

**COMPUTER TYPE:** General-purpose digital.

**NUMBER BASE:** Binary.

**MODE OF OPERATION:** Serial.

**INSTRUCTION TYPE:** Single address.

**NUMBER OF DIFFERENT INSTRUCTIONS:** 16

**MEMORY TYPE:** Magnetic drum.

**MEMORY CAPACITY:** 4096 words.

**WORD LENGTH:** 30 bits plus sign.

**CLOCK FREQUENCY:** 136 KC

**ADD TIME (Excluding Access):** 0.25 milliseconds.

**MULTIPLY TIME (Excluding Access):** 15 milliseconds.

**WEIGHT:** 1000 lbs. nominal.

**SIZE:** 30" x 42" x 60".

**POWER REQUIREMENTS:** 117 volts (±10%) 17 amperes 60 cycles.

#### OPTIONAL EQUIPMENT

**PHOTOELECTRIC READER:** High-speed punched paper tape input for buffer storage.

**MAGNETIC TAPE:** Storage for additional input, output, and computing information.

**MAGNETIC-CORE MEMORY:** For quick access to stored data.

**PUNCHED CARD INPUT.**

**LINE PRINTER:** High speed data-logger printing 14 digits at a time.

**TYPEWRITER SELECTOR:** For multi-station printout.

**RELAY SENSING EQUIPMENT:** For changing computer program in accordance with plant or product requirements.

**GRAPHIC PANELS:** For visual display of information.

**CONSTANTS PANEL:** Manual digital data insertion or readout for operation by non-technical personnel.

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CIRCLE 107 ON READER-SERVICE CARD

AUGUST 1959 107

10 Mc "flip-flop" circuit  
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- high current gain—permits high fan-out ratios (number of paralleled similar circuits per driver-stage output)
- high breakdown voltage and punch-through voltage ratings—the result of the diffusion process
- high power dissipation—150 milliwatts at 25°C—aids in the design of reliable circuits
- high current ratings—improve overall system speed
- rugged overall design—units have unusual capabilities to withstand severe drop tests and electrical overloads
- electrical uniformity—a result of the diffused-junction process used by RCA in the manufacture of Mesa Transistors
- especially well suited for use at pulse repetition rates up to 20 Mc
- exceptionally well suited to applications in saturation-type switching circuits

Information on RCA-2N1300 and 2N1301 Low-Cost Mesa Transistors is available from your RCA Field Representative. For technical data, write RCA Commercial Engineering, Section H-56-NN, Somerville, N. J.

RCA TYPE	Maximum Ratings* Absolute-Maximum Values					Characteristics: Common-Emitter Circuit, Base Input Ambient Temperature of 25°C			
	Collector- to-Base Volts	Emitter- to-Base Volts	Collector Milli- amperes	Transistor Dissipation—mw			Minimum DC Current Gain		Gain Bandwidth Product <sup>†</sup> Mc
				at 25°C	at 55°C	at 71°C	at collector ma = -10	at collector ma = -40	
2N1300	-13	-1	-100	150	75	35	30	—	40
2N1301	-13	-4	-100	150	75	35	30	40	60

\*Maximum collector-to-emitter  
voltage rating = -12 volts

<sup>†</sup>For collector ma = -10 and  
collector-to-emitter volts = -3.

### RCA Field Offices

EAST: 744 Broad St., Newark 2, N. J.  
Humboldt 5-3900

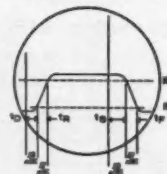
NORTHEAST: 64 "A" Street  
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Hillcrest 4-7200

EAST CENTRAL: 714 New Center Bldg.  
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Oscilloscope wave form shows typical delay, rise, storage, and fall times achieved with 10-ma inverter circuit utilizing the RCA-2N1301 MESA TRANSISTOR.



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# A Transistorized Sampler for Analog Computers

WALTER W. TURNER University of Maine

The study of sampled-data systems on an analog computer requires some means of sampling the input or error signal. A sampler is essentially a cyclic gating network having a short "on" time compared to "off" time.

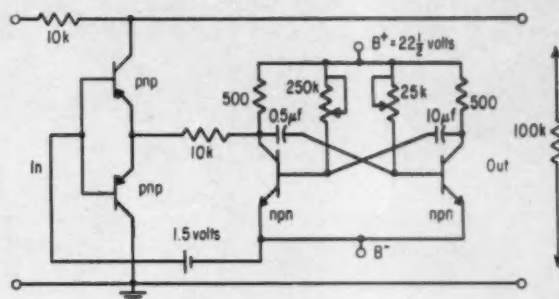
In this sampler, gating is done by a shunt-type switch controlled by a multivibrator. The loss due to the 10k to 100k voltage divider must be compensated for in the computer setup. A common ground for all operational amplifiers requires that the

multivibrator be operated off ground, and the use of transistors rather than tubes permits battery operation, which also removes the possibility of inductive noise from plate and filament power supplies.

The sampling period is controlled by the 250k potentiometer, the sampling or "on" time by the 25k potentiometer. There is some interaction

between controls at the lower resistance values but this has not been a serious limitation. Typical sampling periods and "on" times possible with this circuit are:

Period	"on" time
1.6 sec	0.1 sec
0.75 sec	2-10 millise
10 millise	1-3 millise



# Vapor-Load Steam Ejectors to Control Vacuum

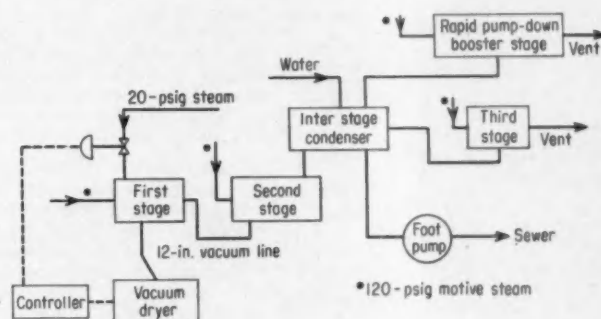
PAUL W. KILPATRICK  
U.S. Dept. of Agriculture, Albany, Calif.

During freeze-drying, vacuum concentration, or other vacuum-processing operations, it may be desirable to control absolute pressure. If a steam ejector is used to produce the vacuum, the absolute pressure at the suction intake to the ejector can be readily controlled by maintaining a constant vapor load. Unlike air loading, vapor loading does not tend to cause unstable operation of some ejectors.

The block diagram shows the three-stage ejector (with third-stage booster for rapid pump-down of system) which services a 60-cu-ft vacuum shelf dryer. The dryer, located on the floor below, is connected to the ejector system via a 12-in. line. Absolute pressure within the dryer can be controlled over the range from 0.5 to 10 mm of mercury

with an accuracy of 0.1 mm. The lower-range limitation is imposed by "dead-end" pump-down of the particular ejector system (in this case, 0.3 mm).

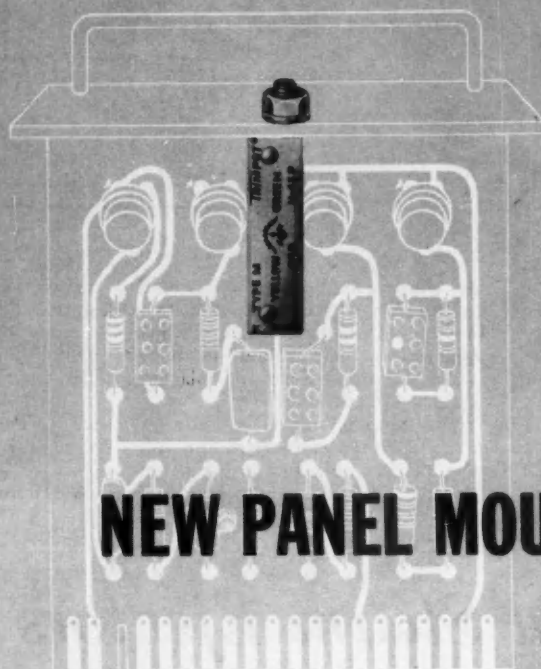
Essentially, the control system consists of: 1) an absolute-pressure controller which senses the absolute pressure within the dryer; and 2) pneumatic diaphragm valve, installed in a steam line and actuated by the output air from the absolute-pressure controller. The instrument-controlled valve bleeds steam into the suction chamber of the first stage of the three-stage ejector. The constant-vapor load thus automatically supplied to



the ejector for a set operating pressure in the dryer is maintained independently of the dryer's evaporative load.

Normal pump-down time for a dryer pressure of 1 mm, about 5 min, can be decreased to 30 sec with the booster stage. One particular ejector has a rated load capacity of 70 lb of water vapor per hour at 10 mm absolute pressure, plus 10 lb of dry air (with booster off). The instrument-controlled valve has a 1/2-in. port in a 1/2-in. body and is supplied with pressure-regulated steam adjustable from 10 to 50 psig. Steam at 20 psig is normally used for controlling absolute pressures in the range 5 to 0.5 mm.

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CIRCLE 110 ON READER-SERVICE CARD

# Commutator Switch Simulates Transport Lag

A. D. WRIGHT  
Elliott Nucleonics, Ltd, London

Transport times in piping carrying CO<sub>2</sub> coolant from the reactor to heat exchangers in a nuclear power plant can vary from 2 to 60 sec, depending on blower settings. These lags are too long for electronic delay circuits, and magnetic-tape delay is inaccurate and digital disc techniques complex.

The best answer is a switch arrangement, motor driven at a speed proportional to the required transport time. In Figure 1 a servo-controlled, motor-driven switch rotates two wipers past 100 contacts. The leading wiper is connected to the input of a unity-gain reading amplifier and the trailing wiper to the output of a unity-gain writing amplifier. The wipers rotate continuously in one direction at a speed determined by the servo drive system so that the time for one revolution is equal to the required DVL. Each of the 100 contacts has a 0.022-mfd capacitor.

The fixed contacts are mounted in a dural ring with ceramic bushings (Figure 2), and the capacitors are connected between the contacts and an insulated ring. The leakage insulation of the contact-capacitor assembly is approximately  $10^{14}$  ohms, representing a loss of charge during the longest delay of less than 0.1 percent.

The wipers are mounted on two

parallel dural arms carried by a rotating Plexiglas disc and fed out via two silver slip rings. The leading wiper reads the voltage on the capacitors acquired during the previous revolution while the second trailing wiper recharges the capacitors to new levels, which are stored for a further revolution time. Output from the reading wiper appears as a series of discrete voltage steps, Figure 3. A small smoothing capacitor in the reading amplifier prevents the output from falling to zero between contacts.

The desired transport time sets the motor speed, and variable input voltages from 3.3-100 volts applied to the servo drive control this speed between 100 and 3,000 rpm. A 100:1 reduction gear train couples the motor to the rotating wipers to give the variable

transport time range of 2-60 sec. Linearity between the transport time and voltage setting is better than 1 percent over the range.

For dc input signals, the transfer ratio is unity to better than 1 percent for signals from plus 100 volts to minus 100 volts. Reading accuracy of ac input signals is calculable from the number of output steps per transit time. With reading and writing wipers spaced at 3.5 times the contact width, 96 samples are read per transit.

It is theoretically possible to obtain delays longer than 60 sec by slowing the motor speed, but system linearity falls off due to capacitor-charge leakage during the revolution. Coupling two units in series gives smoother output waveforms for DVL's up to 120 sec.

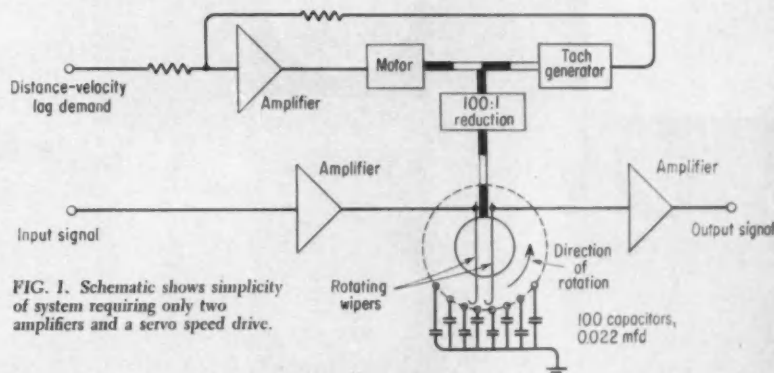


FIG. 1. Schematic shows simplicity of system requiring only two amplifiers and a servo speed drive.

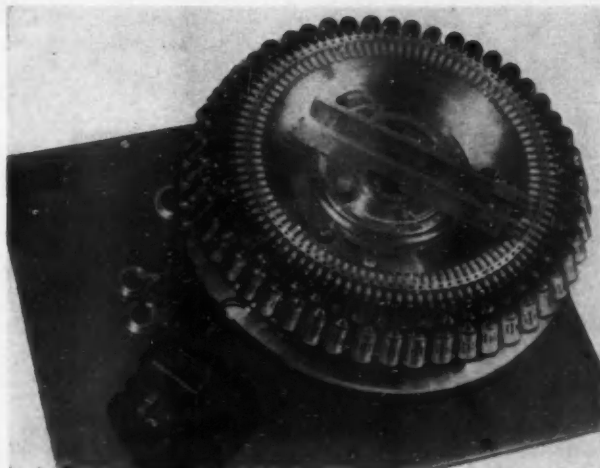


FIG. 2. Construction connects 0.022-mfd capacitors to each of 100 contacts.

FIG. 3. Lower recording is input signal. Top is 100-volt peak-to-peak output, delayed by 60 sec.



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# Honeywell



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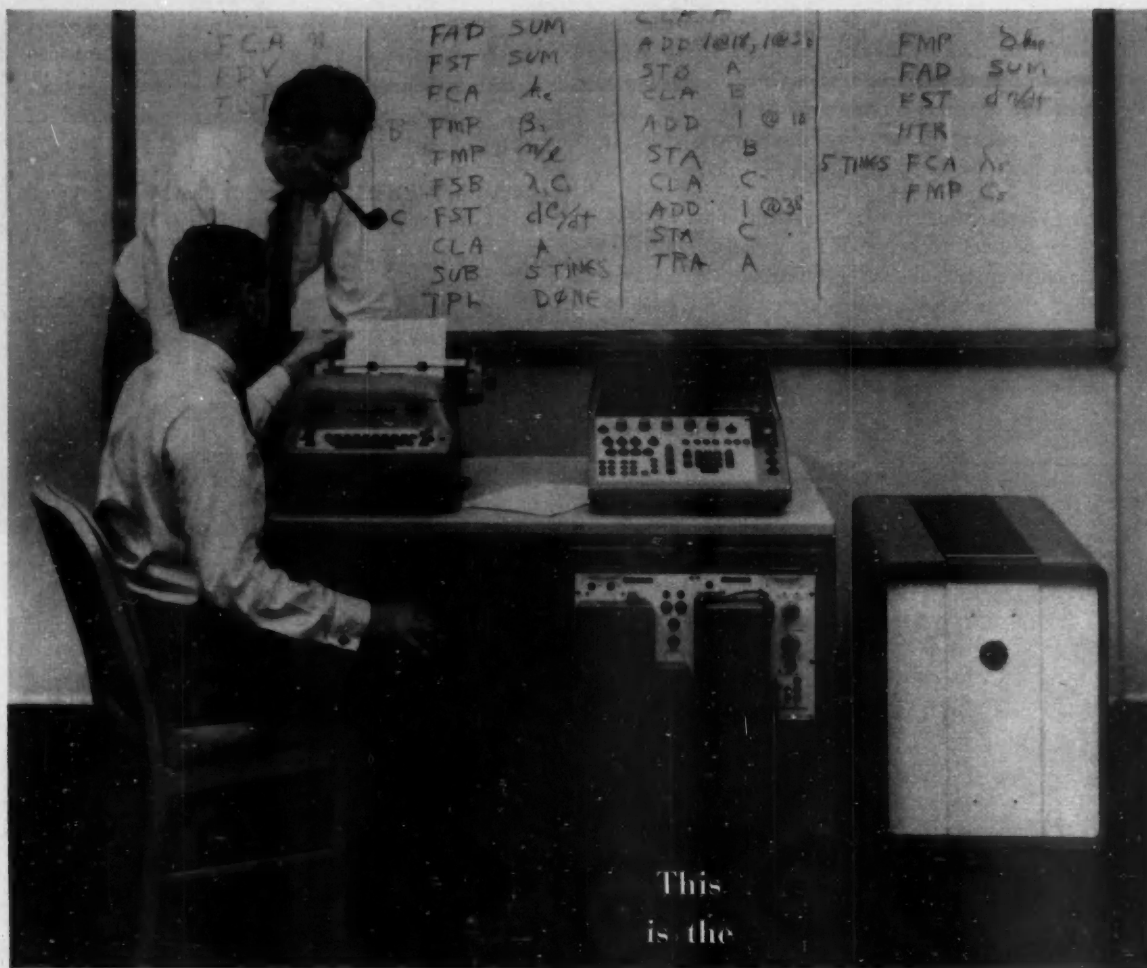


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# NEW PRODUCTS

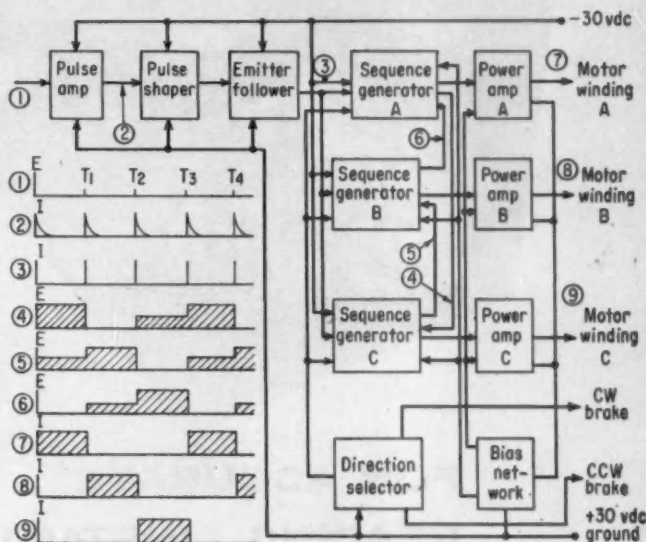
## POWER STEPPING MOTORS for digital control systems

Five power stepping motors, together with associated solid-state and thyatron controls, make up the new Digitork line of digital system components. Designed primarily for actuator service, the motors provide a precise bi-directional step output for input pulse rates as high as 3 Kc, without conversion or feedback. Features include: high instantaneous response rates; high step resolution; good power performance; and accuracies within 1 deg or better.

Basically, each motor consists of three separate magnetic sections mounted on a common shaft. Each section contains a multipole rotor and stator. Pole faces of all three rotors are in perfect alignment, but the stators have been staggered so that their pole faces have a relative displacement of one-third the angular pole spacing. With this arrangement, sequential pulsing of the stator windings produces a stepwise rotation of the output shaft.

A simple over-running clutch-brake mechanism eliminates the problems of hunting and oscillation. It prevents any reversal of the output shaft as long as the input pulse sequence remains unchanged. When the pulse sequence is reversed, the clutch-brake action is also reversed.

The block diagram at the right shows a typical solid-state control unit designed to provide the sequential excitation of the motor windings. Not shown are three resistive load networks in series with the motor windings. These serve to improve the motor's high-speed performance.



The table below gives some of the more important performance characteristics as well as physical dimensions for each of the five motors currently available. Photo to the right of the table shows an M-35 motor with one quadrant of the stator sections cut away to reveal its internal construction.—The Teller Co., Butler, Pa.

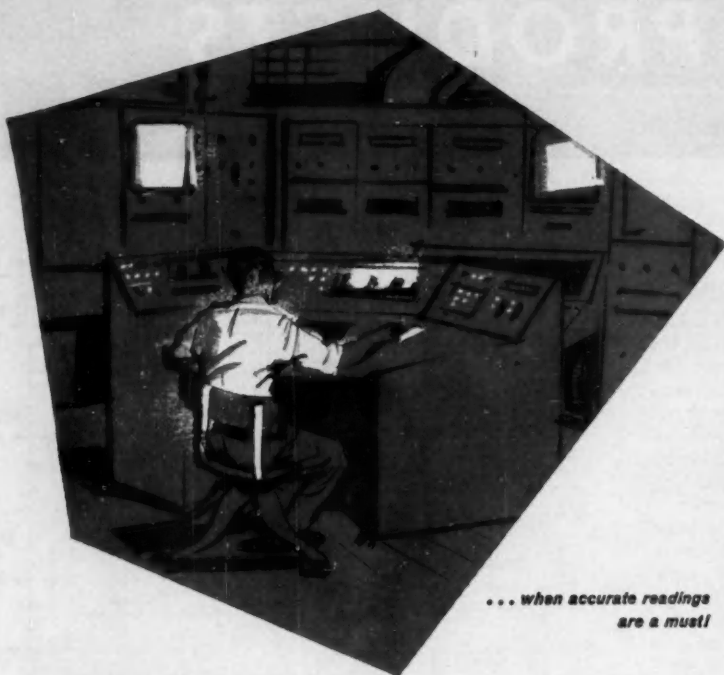
Circle No. 200 on reply card

Model	S-15	S-18	M-35	M-60	H-100
Steps/rev	36	36	48	72/108	60
Stall torque	3 in. oz.	5.5 in. oz.	55 in. oz.	30 in. lb.	160 in. lb.
Rated torque	1 in. oz.	2.5 in. oz.	35 in. oz.	20 in. lb.	100 in. lb.
Rated speed	1000 rpm	1000 rpm	1000 rpm	300 rpm	300 rpm
Rated freq.	600 cps	600 cps	600 cps	500 cps	500 cps
Control	Solid state	Solid state	Solid state	Optional	Thyatron
Max. temp.	100 deg C	100 deg C	120 deg C	135 deg C	135 deg C
Weight	20 oz.	33 oz.	9 lb.	28 lb.	185 lb.
Dimension "A"	1.437 in.	1.750 in.	3-1/2 in.	6 in.	9-1/4 in.
Dimension "B"	4 in.	4 in.	6-1/8 in.	9-1/8 in.	20 in.
Dimension "C"	—	—	3-9/16 in.	6-1/4 in.	10 in.

LEFT: Performance data on five production models. BELOW: Photo of a 48-step, medium size unit.



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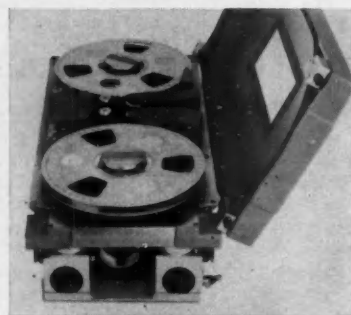


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CIRCLE 116 ON READER-SERVICE CARD  
CONTROL ENGINEERING

## NEW PRODUCTS

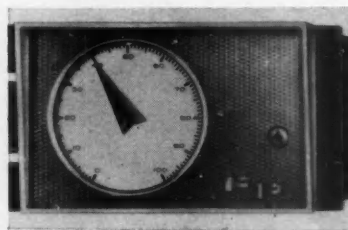
### DATA HANDLING & DISPLAY



#### RUGGED AND RELIABLE

Designed for airborne and other mobile applications, the AR-200 magnetic tape recording system consists of the tape transport shown here, an amplifier unit that will house seven analog or eight digital record amplifiers, and, if necessary, a suitable power converter. Latest track configurations are available, featuring up to 32 digital recording tracks or 16 digital and 7 analog tracks on 1-in. tape. A remote control assembly for panel mounting contains a tape-remaining meter and lights to indicate the operating mode. Other accessories include servo tape speed controls, a self-contained test unit, and a system for combining transports to produce an uninterrupted long-term recording. Standard tape speeds are 1½, 3½, 7½, 15, 30, and 60 ips. A complete 14-track system draws only 150 watts, and needs less than 2 cu ft of space.—Instrumentation Div., Ampex Corp., Redwood City, Calif.

Circle No. 201 on reply card



#### SERVO-DRIVEN

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CIRCLE 117 ON READER-SERVICE CARD →

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# THERMOCOUPLES MADE PRACTICAL

...or how a completely floating and isolated differential DC amplifier can be of assistance in obtaining overall system accuracies of 1% to 0.1% when measuring the output of grounded thermocouples or strain gages.

Designers and users of data-handling systems, particularly systems for evaluating high-performance rocket or jet engines, are constantly under pressure to provide higher and higher measurement accuracies. According to recent statistics, a large percentage of these measurements involve narrow-band data from grounded thermocouples. Even on a bench, the measurement of temperature in a DC to 100-cycle bandwidth with 1% accuracy isn't too easy, and 0.1% measurements get pretty messy. Now, if you have fifty thermocouples and they happen to be or have to be grounded at the source, and the source is a rocket or jet engine separated from your amplifiers by, say, 300 feet of interconnecting cable, and the amplifiers are driving a load such as a large data-handling system that must be grounded, you are probably in trouble. In fact, with a system anything at all like this, it's likely that you had great difficulty getting 1% system accuracy and found 0.1% accuracy virtually impossible to obtain.

5 more microvolts of trouble from outside causes, or a little less than 2 microvolts RMS AC at 60 cycles. Can we expect 2 microvolts of trouble from ground loops? You bet we can! The normal, average common mode voltage at installations we know of is approximately 1 volt RMS at 60 cycles. In a number of cases, this common mode potential is as high as 4 volts at 60 cps.

In an attempt to better this situation by a rather common remedy, we shall tie a big fat bus bar between the rocket engine and the amplifier case ground, as shown in Figure 1. Our bus bar will be an eight-inch pipe filled with water, 300 feet long, with an impedance of about 0.2 ohms at 60 cycles. (An actual installation.) The common mode voltage generator shown in Figure 1 will have some impedance associated with it, and the ratio of this impedance to the bus bar impedance will determine how much we reduce the common mode voltage. If the impedance of the common mode generator is 0.2 ohms, we will reduce 1 volt

bus bar is connected through the rocket engine to the exact center of the thermocouple, the input signal will be reduced to half. If the thermocouple impedance (or, more accurately, the emf generating part of the thermocouple) is all in series with the ground (low) side, the signal would be almost zero. You can see now why we said that obtaining 1% accuracy was difficult and 0.1% accuracy virtually impossible.

Are we completely whipped? Yes and no. If our system must look exactly like that of Figure 1, we probably are. If we can change the system somewhat, perhaps not. What we need to beat this common mode voltage problem is some impedance in series with our ground loop. If we can float the amplifier, or the thermocouple, we can solve or at least improve the situation. It's actually impossible to float a thermocouple bonded to a rocket or jet engine. Even if the whole stand sits on concrete, there will still be a big potential difference between engine and amplifier. This leaves the amplifier end to work on.

You have probably noticed that we show a grounded load, but not a grounded amplifier in Figure 1. This is realistic. It is possible, for example, to float our 111 series single-ended DC amplifiers by about 500 kilohms at 60 cps. This would be enough to keep us out of trouble with up to 10 millivolts of common mode voltage, since, in this case, we would produce only 2 microvolts of noise ( $100/500K \times 10 \text{ mv}$ ). We are assuming that the load can be floated sufficiently so that the impedance of the low side of the amplifier to ground is the only consideration. However, if the load must be tied to ground as in Figure 1, either directly or through the low impedance of long cables between amplifier and load, then we cannot use a single-ended amplifier. Or, even with the load floated, if the common mode voltage is too high, we cannot use a single-ended amplifier.

## THE DIFFERENTIAL AMPLIFIER

In the foregoing discussion we have pointed out that single-ended amplifiers can severely limit the performance of systems employing both grounded transducers and grounded loads. The differential amplifier (sometimes called floating amplifier), if it meets certain re-

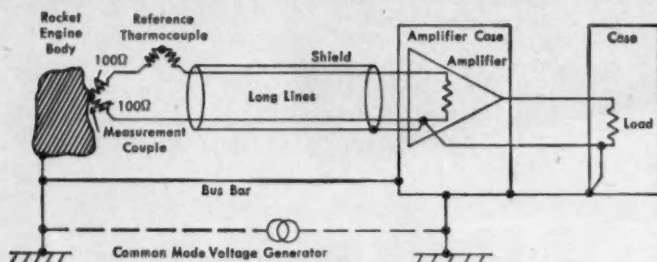


Figure 1

## WHAT'S THE PROBLEM?

In Figure 1, we see a grounded thermocouple with a reference couple, 300 feet or so of shielded input leads from the couples to the amplifier, and a single-ended DC amplifier driving a grounded load. (For the moment, we will ignore the bus bar.) This is a typical system. It doesn't give very good accuracy. Nevertheless, it is a typical system. In our experience, the problem with such systems has always been noise, noise which results from ground loops. The troublesome part of this noise will consist of hum at the power line frequency. It will be random in magnitude and phase at the amplifier, precluding accurate cancellation. This noise, this difference in potential which exists between the thermocouple ground point and the amplifier ground point—since it is common to both input leads—is called common mode voltage, as shown in Figure 1. And any noise voltage appearing here will be applied directly to the input of the amplifier.

Let's examine the magnitude of the problem. A typical thermocouple will have a peak output of about 10 millivolts. If the system resolution is to be 0.1%, then the maximum peak error caused by noise, drift, non-linearity and what-have-you can't exceed 10 microvolts. Good single-ended amplifiers (such as KIN TEL's 111 series) will contribute less than 5 microvolts of equivalent input error from all of these causes. This means we can tolerate only

of common mode voltage to 0.5 volts. If the common mode generator impedance is 20 ohms, the common mode voltage will be reduced to 5 millivolts, or a little more than two thousand times greater than the 2 microvolts RMS we said we could stand. Even if the common mode voltage had been 1 millivolt instead of 1 volt, with 20 ohms of common mode generator impedance, the bus bar would reduce the common mode voltage to only 5 microvolts. This is still too much.

Unfortunately, most of the figures we have chosen are a little on the favorable side. More than likely, the common mode voltage will be 1 volt, more than likely the common mode generator impedance will be less than an ohm, and more than likely you won't have a bus bar with as little as 0.2 ohms impedance at 60 cycles. In fact, there's even more to the big bus bar fallacy than this, for if the generated common mode voltage is partly caused by electromagnetic pickup from high-voltage power lines or other sources, it may actually increase after the bus bar is installed. Admittedly, the bus bar may be far removed from power lines, but it's not even safe to be in the same world with high-voltage, high-current power lines when only 2μv of noise will ruin you. The bus bar may also short out part of the input signal. We show the thermocouple as a device with 100 ohms each side of the point at which it contacts the rocket engine. If this is true, and our

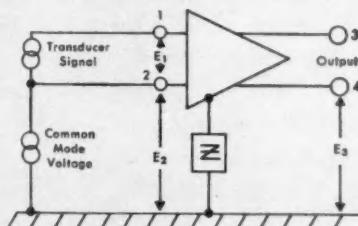


Figure 2

quirements, will permit the use of grounds at both ends of a long line without forfeiting adequate system performance. Figure 2 is a diagram of the basic differential amplifier. Note that, unlike the single-ended amplifier in which volt-

ages  $E_2$  and  $E_3$  would be equal, input terminal 2 and output terminal 4 are not common. The output of the true differential amplifier is only equal to the difference in potential between input terminals 1 and 2, times the gain of the amplifier, and is not affected by any voltage between terminal 1 and ground or terminal 2 and ground. Thus,  $E_2$ , the common mode voltage, does not affect the input. The major figure of merit of a differential amplifier is common mode rejection, or how much of the common mode voltage,  $E_2$ , is converted to normal mode voltage, transducer signal  $E_1$ . For example, if common mode voltage of 1 volt produces 1 microvolt of equivalent input signal, the common mode rejection is 1,000,000 to 1 (120 db).

There are two basic types of differential amplifiers. The most familiar is probably the balanced amplifier shown in Figure 3. This amplifier requires an exceptionally well-balanced input if common mode rejection is to be good. Figure 3 can be redrawn as the bridge circuit shown in Figure 4. From this it

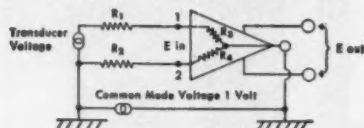


Figure 3

can be seen that the common mode rejection is determined by the equality of  $R_1/R_3$  and  $R_2/R_4$ . With no transducer input signal and 1 volt of common mode voltage, an unbalance of only 2 ohms will introduce 20 microvolts of noise, which is a common mode rejection of 50,000 to 1. Even a simple system employing only a measurement thermocouple and a reference thermocouple may well have a resistive unbalance of a 100 ohms or more. Considering the reactive component of the impedances involved and the fact that most large installations employ calibration or level-setting potentiometers in the transducer circuit, it is desirable to have an amplifier that will provide high common mode rejection with up to several thousand ohms input unbalance. This balanced-input differential amplifier cannot do. Internal limitations—such as the necessity of having carefully balanced feedback circuits—

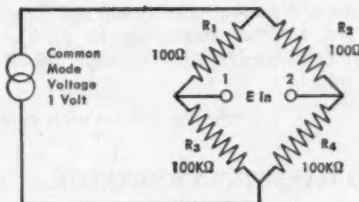


Figure 4

also conspire to limit the performance of balanced amplifiers.

If the balanced amplifier can be floated, that is, not tied to ground as it is in Figure 3, common mode rejection can be improved. Since good input to output isolation cannot usually be obtained in balanced amplifiers, the load must be floated too. Considering all of these fac-

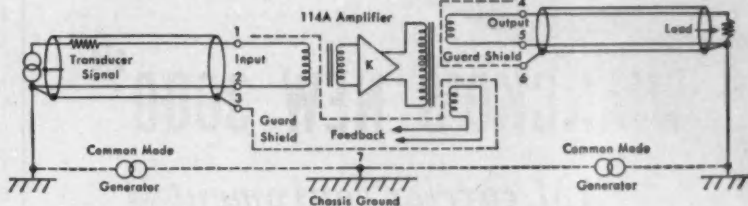


Figure 5

tors, it is difficult in practice to obtain a common mode rejection of more than 1000 to 1 with the balanced amplifier. Nevertheless, it will improve system performance in the few cases where common mode voltage is low, but still too high to provide adequate performance with no common mode rejection at all. If common mode voltage is low enough, it is probably better to use a single-ended amplifier. Balanced amplifiers are generally more expensive than single-ended and, except for common mode rejection, their performance isn't usually as good.

All of our common mode voltage problems could be solved with an amplifier that had nearly infinite impedance between input circuit and amplifier case or chassis ground, and further, had only magnetic coupling between input and output with virtually no stray capacitance. Then the input would be isolated from the output and it wouldn't make any difference whether the load were grounded or not. Is there such an amplifier? Yes.

KIN TEL's 114A Differential DC Amplifier meets all these requirements and more. Common mode rejection of the 114A is 1,000,000 to 1 or better for 60 cps voltages, and practically infinite for DC. And it provides this rejection with up to 10,000 ohms unbalance in either input lead. To obtain this kind of performance, it can be seen that  $R_1$  and  $R_4$  in Figure 4 would have to be 100,000 megohms, and, at 60 cps, leakage capacity to ground could not exceed about 0.3 micromicrofarads for each side of the input. In order to meet these tough isolation requirements, the KIN TEL 114A employs guard shielding similar to that used in fine AC bridges. These guard shields surround the entire input and output circuits and are extended out to the transducer and load by means of input and output cable shields. Figure 5, a considerably simplified version of the 114A, illustrates this principle. (The transformers are given DC response by means of input chopper and output demodulator circuits which are not shown.) If the guard shields were perfect, there would be no capacitance and therefore infinite impedance between input and output signal leads and chassis ground for the common mode voltage.

In practice, the KIN TEL 114A provides 10,000,000 megohms and less than 0.3 micromicrofarads impedance between each input signal lead and the amplifier case or chassis ground. Output circuit impedance to chassis ground is almost this high, and input and output are completely isolated from each other. In other respects—linearity, gain stability, noise, drift—the 114A closely equals the performance of the very best single-ended DC amplifiers. However, bandwidth is forfeited for common mode rejection. This is a penalty the present

state of the art requires of all completely floating and isolated differential amplifiers that are capable of providing high common mode rejection with an unbalanced input. Fortunately, the 100-cycle bandwidth of the 114A is more than adequate for bonded thermocouples, which cause most common mode voltage problems, and is usually adequate for strain gage measurements. The advantage of using the 114A with strain gauges is that it eliminates the necessity of having exceptionally well-isolated power supplies and permits using one supply for a number of gauges.

#### IN SUMMARY

When you are designing a large, fairly complex narrow-band data-handling system with long lines between a grounded transducer and amplifier and/or amplifier and load, you will have ground loop problems. To determine the magnitude of the problem, measure the voltage, electromagnetic field strength, and earth impedance between transducer and amplifier ground points. From this information you can roughly calculate whether installation of an expensive bus bar between amplifier and transducer will provide enough reduction in common mode voltage. Examine power sources and loads that may be generating unwanted currents. Perhaps they can be ungrounded. If common mode voltage is still too high to provide desired system resolution (it probably will be), use a differential amplifier.

If you have a common mode voltage problem, and you need a differential amplifier, it must have very high common mode rejection at 60 cps. If 60-cycle rejection is only marginal, you may be in serious trouble at slightly higher frequencies. The amplifier must be capable of providing this common mode rejection with whatever input unbalance is present. If calibration or level-setting potentiometers are used to permit commutation of multiple channels, this unbalance can be several thousand ohms. To retain common mode rejection in the quite likely event that the load is grounded, the input circuit of the amplifier must be well isolated from the output circuit. And, if long output cables are used, the amplifier output circuit must be isolated from ground to almost the same degree as the input. Otherwise, the common mode voltage between output and load can cause trouble. All signal cables and shields must be arranged to provide both adequate shielding and maximum ground loop impedance for minimum ground loop current. Finally, call your nearest KIN TEL Engineering Representative, you'll want a demonstration of the 114A Differential DC Amplifier.



Write today for descriptive literature or demonstration. 5725 Kearny Villa Road, San Diego 11, California

# WIANCKO'S NEW 3000\*

*AM carrier equipment*



Exceptionally reliable in the past, Wiancko's new 3000 cycle carrier equipment represents a decade of evolutionary refinement. The basic equipment has been the heart of instrumentation systems for many successful rocket engine manufacturers, wind tunnel operators, and missile propellant producers. To meet today's more demanding accuracy and reliability requirements, these people are equipping their facilities with the new 3000!

- *convenient electrical calibration*
- *high level signals*
- *modular design*

Advanced component design offers a variety of options for compatibility with both analog and data systems. A minimum of vacuum tubes combined with conservatively rated circuitry, provides the maximum in reliability and utility. For more information on the new 3000 write for bulletin 109.



**Wiancko Engineering Company**

255 North Halstead Avenue • Pasadena, California

CIRCLE 120 ON READER-SERVICE CARD

CONTROL ENGINEERING

## NEW PRODUCTS

meters. Its 4½ in. circular dial may be calibrated to read either actual or percent flow. An ac null-balance potentiometer type, the instrument boasts an accuracy within 2 percent of full scale and a repeatability within 1 percent. Compact package weighs only 15 lb.—Fischer & Porter Co., Hatboro, Pa.

Circle No. 202 on reply card



### RAPID CONVERSION

The DYKOR D101 magnetic-to-paper tape converter provides fast, accurate off-line communication between a computer and remote Teletype stations. It will handle any computer output in which the code is 6-bit parallel plus a parity bit and serial by character and convert this to its corresponding form on standard paper tape. A high speed perforator punches 240 characters per sec, while a control plugboard permits insertion of carriage returns, line feeds, and blanks. Figure-to-letter shifts are inserted automatically whenever the output calls for such a translation. Transistorized printed circuits and self-checking facilities contribute to its high reliability.—Digitronics Corp., Albertson, L. I., N. Y.

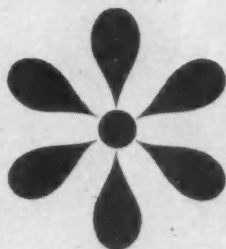
Circle No. 203 on reply card

### CHARACTER GENERATOR

Suitable for either continuous display of tabular information or insertion of written data into pictorial displays, Philco's new high-speed electronic character generator provides a selection of up to 64 characters of any shape or size. These are located on a character mask within the basic generator module. Alternate masks can provide an entirely different set of characters. In a typical application,

Kodak

NEW FROM KODAK



# LINAGRAPH PERMANIZING DEVELOPER



Three good instrument manufacturers, dear friends of ours, have been pushing for all they're worth a type of oscillograph that puts out a visible record instantly, without chemical processing. Maybe you have one or a bank of them. They're terrific. They use Kodak Linagraph Direct Print Paper. Occasionally—maybe often—you get a record that you wish had the long life that chemical processing gives. Now you can have your cake and eat it. Just dissolve this new powder in a gallon of hot water, dunk as directed, fix, wash, and dry. No darkroom needed. Your Kodak dealer has it right now.

Photo Recording Methods Division, EASTMAN KODAK COMPANY, Rochester 4, N. Y.

CIRCLE 121 ON READER-SERVICE CARD

AUGUST 1959

121



## New UNION readout instruments withstand shock, vibration and extreme temperature changes

Union Switch & Signal's new READALL® readout instrument replaces complicated systems of lights and relays for reading, storing or transferring all types of information for industrial and military applications. It is not to be confused with conventional indicating devices.

**Designed to meet requirements of MIL-E-5422D.** The new READALL readout instrument is precision-built and provides instantaneous and continuous operation under conditions of shock, vibration and extreme ranges in temperature. The digital display includes characters in numerical sequence from 0 to 9 plus two blank spaces.  $\frac{7}{32}$ -inch characters can be illuminated red or white as desired; when not illuminated, they appear white against a black background.

**Reliability.** Performance through one million random operations is an inherent feature of the new READALL instrument. Each module is gasket-sealed in its case to exclude moisture and seal out foreign particles. An especially thin enclosed DC motor, containing ball bearings, permits more efficient operation.

**Modular Construction.** A unique feature of the readout instrument is its modular construction. It can be used individually or in groups to display multiple characters in a single case.

**Direct Code Translation.** The operation of the READALL readout instrument is based on a positioning system using a four-bit code. The visual display is the result of a direct electro-mechanical conversion of a binary signal to a decimal read-out. There is no need for additional conversion equipment. Separate code and motor circuits permit the use of the readout instrument in low-level circuitry.

**Electrical and Visual Data Storage.** Once positioned, the information is displayed until a new code is transmitted to the instrument. No power is consumed while the information is retained. This data may be stored or read-out electrically for further transmission or recording.

**Operate Time.** The operate time varies from 0.1 second to 1.0 second depending on character position.

**Weight and Size.** Maximum weight including case is seven ounces; without case, four and one-half ounces. Size encased is  $5\frac{13}{64}$  inches long,  $1\frac{47}{64}$  inches high and  $\frac{39}{64}$  inch wide. The new READALL instrument is designed for operation over a temperature range of  $-54^{\circ}\text{C}$  to  $+71^{\circ}\text{C}$  in humidities up to 100% and altitudes up to 70,000 feet. For more information, write for Bulletin 1019.

\*Trademark

See us at Wescon Show August 18-21  
at Booths 2613-2615.

*"Pioneers in Push-Button Science"*



**UNION SWITCH & SIGNAL**

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY —

PITTSBURGH 18, PENNSYLVANIA

CIRCLE 122 ON READER-SERVICE CARD

CONTROL ENGINEERING

## NEW PRODUCTS

the generator uses a standard dual-deflection cathode ray tube. Major input positions are applied to the magnetic deflection yoke, while voltage waveforms applied to the electrostatic deflection plates sweep out the desired character. Digital inputs may be used for character selection and writing speeds can be varied up to 50,000 characters per sec.—Philco Corp., Philadelphia, Pa.

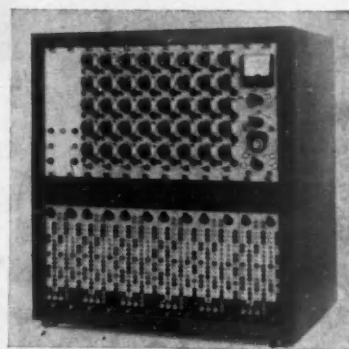
Circle No. 204 on reply card

### PLUS...

(205) Gilmore Industries, Inc., Cleveland, Ohio, has developed a new multi-channel plotter for scanning and plotting strain vs load data on individual graphs. . . . (206) A low-cost temperature recording system, designed to handle up to 75 thermocouple inputs, was recently announced by Datex Corp., Monrovia, Calif. . . . (207) Navigation Computer Corp., Philadelphia, Pa., offers two new transistorized units for handling non-return-to-zero data. . . . (208) From Fischer & Porter Co., Hatboro, Pa., comes word of a new 4-inch strip chart recorder with an inking system that provides a full month's record without refill.

Circle No. 205, 206, 207, or 208 on reply card

## RESEARCH, TEST & DEVELOPMENT



### EASILY EXPANDED

The AD-1, a new low-cost electronic differential analyzer, may be readily expanded to provide a medium-size general-purpose analog computing facility. Its operational amplifiers are all mounted in  $4\frac{1}{2}$  by 14 in. modules, each containing four amplifiers,

# What a build!

... solid state components

in New Fenwal

*Temperature Controller combine precision with extra reliability*

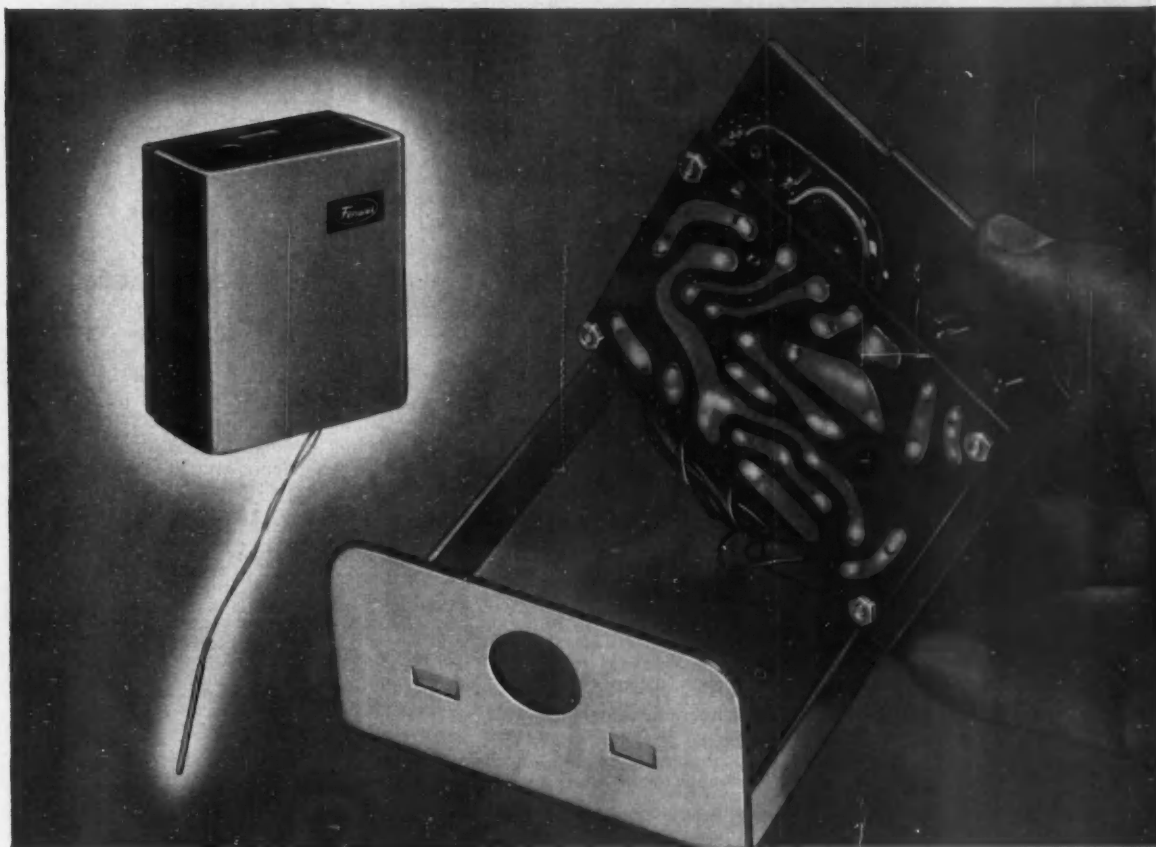
Here's a new, low-cost temperature controller that's really built "solid": thermistor sensing element, printed circuit, transistors. *No wonder the Fenwal 535 Temperature Controller provides high precision, trouble-free operation and long life!*

The Model 535's solid state components pay off in simplicity and dependability. The thermistor sensor mounts up to hundreds of feet from the controller using uncompensated electric wiring; has virtually limitless life; feeds into a rugged transistor amplifier. *No moving parts . . . nothing to wear out!*

The Model 535 is the latest advance in the low-cost line of Fenwal Temperature Controllers specifically developed to fully exploit the advantages . . . rapid response, compact size, reliability . . . of solid state components. *And Fenwal, alone, has integrated production of both controllers and thermistors.*

Use the Fenwal Model 535 Controller for fast response and close control of temperatures from  $-25^{\circ}\text{F}$  to  $+600^{\circ}\text{F}$  in plastics, packaging, or other critical applications. Get full details from a Fenwal Sales Engineer or write for catalog. Fenwal Incorporated, 298 Pleasant Street, Ashland, Mass.

Single point Model 535 Fenwal Temperature Controller has  $2^{\circ}\text{F}$  setting accuracy and sensitive operating differentials from  $0.4^{\circ}\text{F}$  to  $1.2^{\circ}\text{F}$ . Current capacity: 5 amps. 115 volts AC — 10 amp. model later in 1959.



ANOTHER  
EXAMPLE  
OF HOW

**Fenwal**

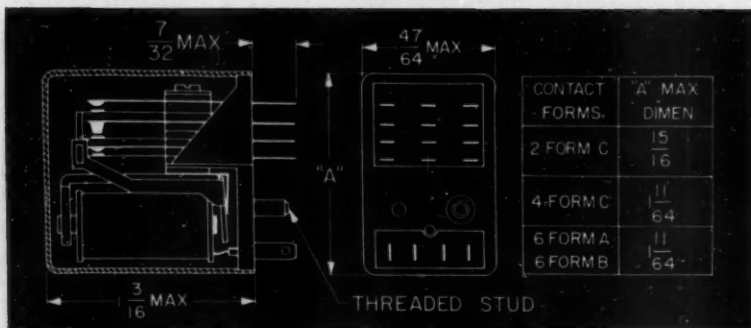
CONTROLS TEMPERATURE . . . PRECISELY

# MINIMUM SIZE Maximum Dependability LOW COST



ACTUAL SIZE

The new T-154 relay is now being manufactured by Allied Control at Plantsville, Conn.



## General Features:

### Operate Sensitivity:

From 90 milliwatts for 1.3 ohm coil to 160 milliwatts for 15,000 ohm coil up to 2 Form C

From 200 milliwatts for 1.3 ohm coil to 400 milliwatts for 15,000 ohm coil up to 6 Form A

**Coil Resistance:** Up to 15,000 ohms

**Coil Voltage:** Up to 140 volts d-c

### Contact Rating:

Low Level to 1 ampere 29 volts d-c or 115 volts a-c resistive. 5 ampere contacts are available

**Contact Arrangement:** Up to 6 Form A, B and 4 Form C

**Operate and Release Time:** 7 milliseconds max. at 1 watt

**Shock:** 10 g's

**Vibration:** 10 to 55 cps at .062" double amplitude

**Enclosure:** Dust proof and hermetically sealed

For complete information write for Bulletin T154

**ALLIED CONTROL**  
ALLIED CONTROL COMPANY, INC., 2 EAST END AVENUE, NEW YORK 21, N. Y.

CIRCLE 124 ON READER-SERVICE CARD

CONTROL ENGINEERING

## NEW PRODUCTS

banana-jacks, and associated components for linear computation. Power supply, control circuitry, coefficient pots, and all nonlinear equipment are mounted in similar modules. An initial installation may contain from 4 to 32 amplifiers; a patchboard conversion unit allows further expansion to 48 amplifiers. Nonlinear equipment includes passive-circuit square-law multipliers and diode function generators. Prices for complete computers start at \$1,750.—Applied Dynamics, Inc., Ann Arbor, Mich.

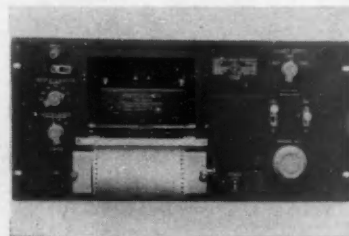
Circle No. 209 on reply card



## IMPEDANCE BRIDGE

The Type 1650-A impedance bridge, pictured above, features an exclusive new mechanical ganging device, called Orthonull, that facilitates measurement of low-Q inductors or high-D capacitors. Accuracy is within 1 percent for all R, C, and L measurements and within 5 percent for Q and D measurements. Self-contained and portable, the instrument sells for \$440.—General Radio Co., Cambridge, Mass.

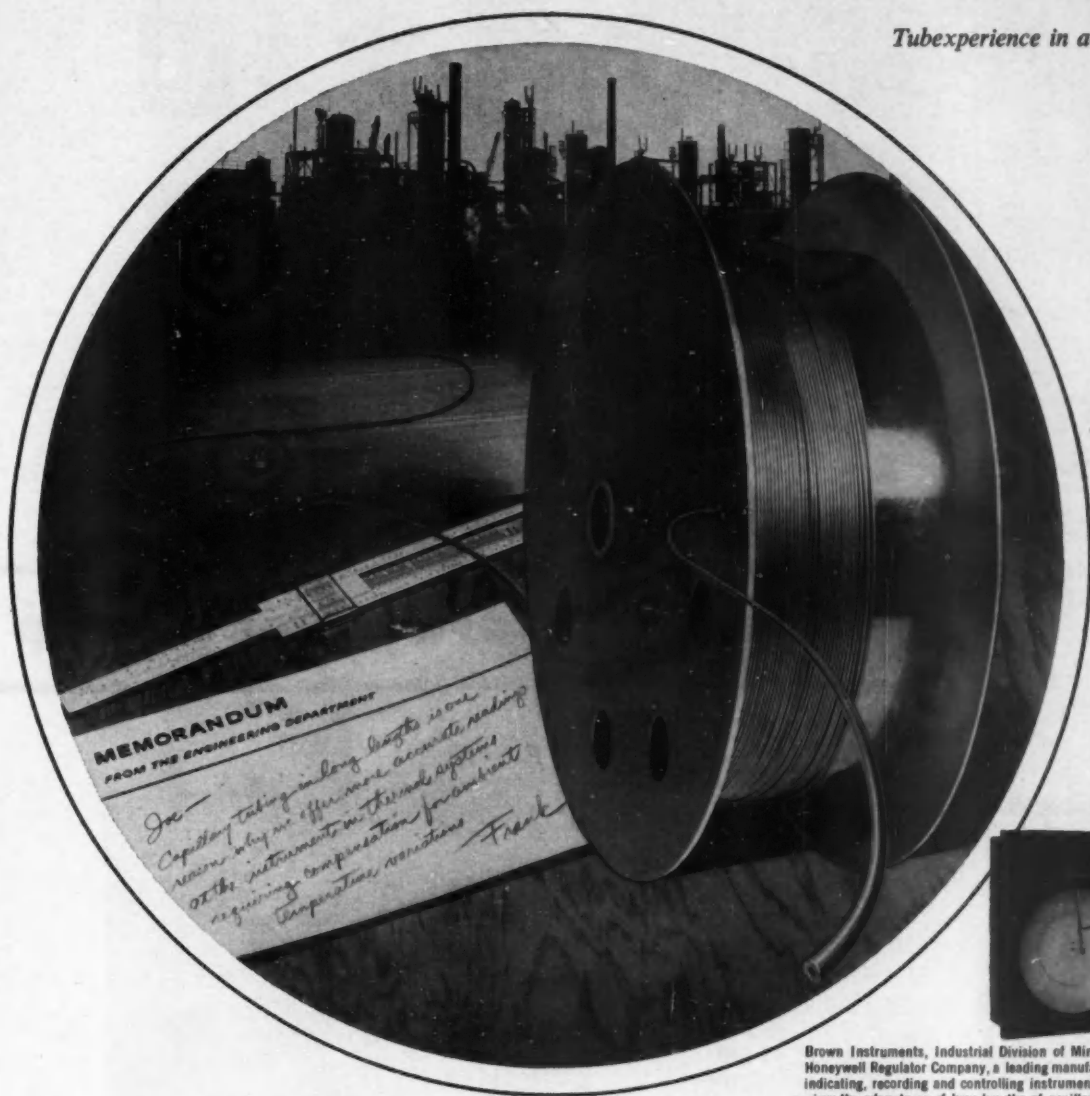
Circle No. 210 on reply card



## PLOTS SOUND LEVELS

In the Type 1521-A transistorized graphic level recorder, a high-speed null-seeking servo positions a logarithmic potentiometer and a pen to record the rms level of an ac voltage, either as a function of time or some

*Tubexperience in action*



Brown Instruments, Industrial Division of Minneapolis-Honeywell Regulator Company, a leading manufacturer of indicating, recording and controlling instruments, recognizes the advantages of long lengths of capillary tubing.

## Up to 3000 ft. of capillary tubing in 1 piece

Seldom does an instrument installation require 3000 ft. of capillary tubing in one piece—the quantity is normally much less. But the advantages of long lengths are numerous. A simple long length of capillary tubing has greater ID uniformity than a series of short lengths separately produced. This permits more accurate transmission of data between instruments controlling a process. Instrument manufacturers find that long lengths reduce scrap. They also lessen the number of setups required and the costs of inserting the

capillary tubing in flexible metallic protective sheathing.

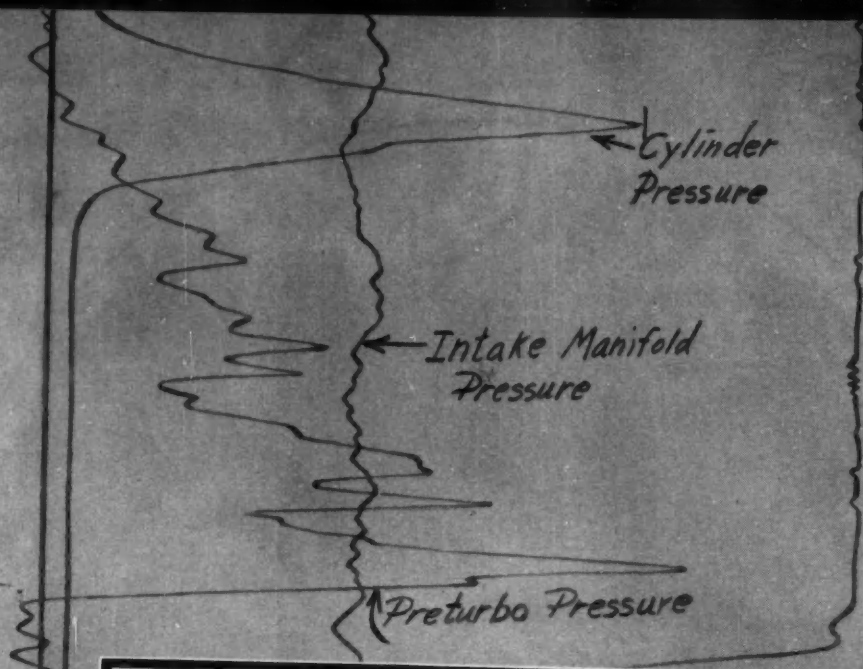
Superior has spent years in the development of manufacturing processes and quality control procedures for the production of close tolerance tubing. ODs range up to  $\frac{3}{16}$  in., IDs from .004 through .040 in. Analyses include Types 304, 316, 321, 347 and 446 stainless; also Monel, Inconel, nickel and carbon steel alloys. Data Memorandum No. 11 gives complete details—let us send you a copy. Superior Tube Company, 2026 Germantown Ave., Norristown, Pa.

Monel and Inconel are registered trademarks of International Nickel Co.

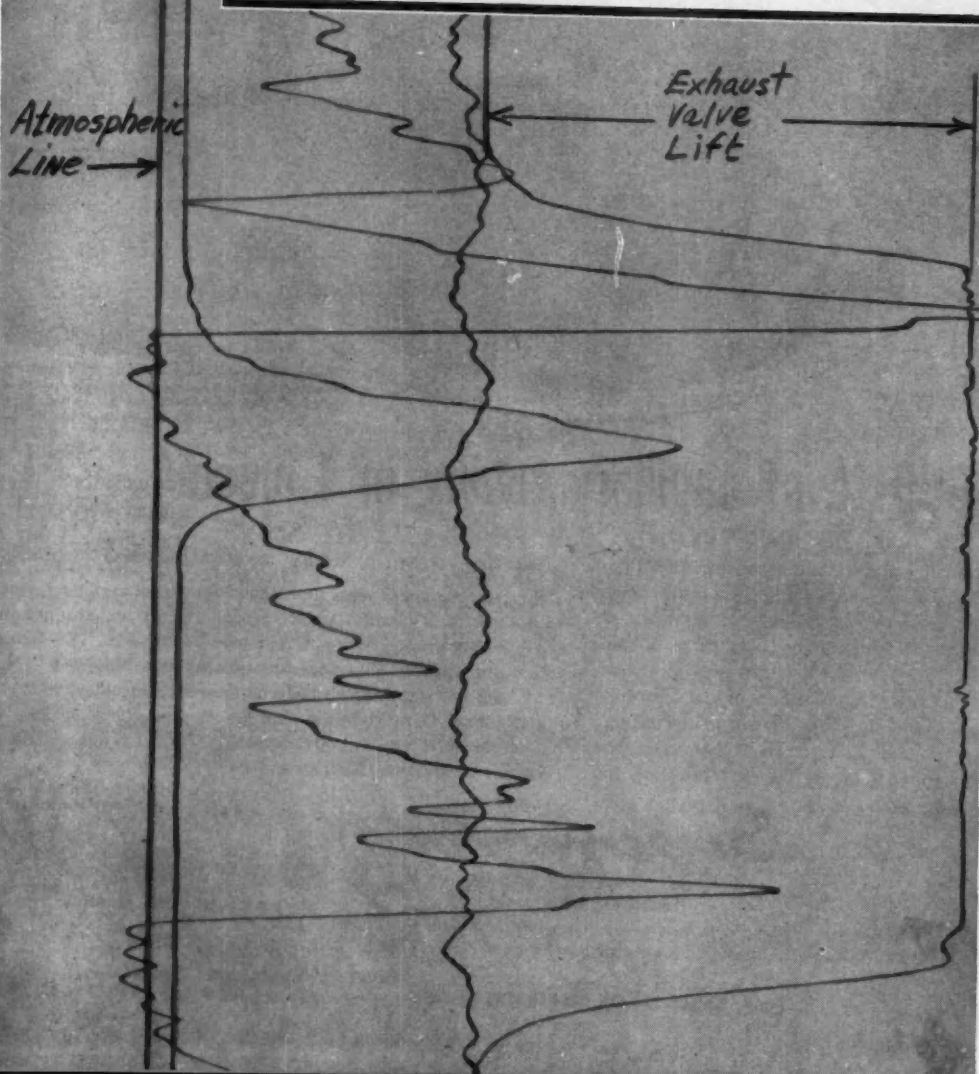
# Superior Tube

The big name in small tubing  
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All analyses .010 in. to  $\frac{3}{16}$  in. OD—certain analyses in light walls up to  $2\frac{1}{2}$  in. OD  
West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST



**This is a record of leadership**





The Worthington Corporation used a Honeywell 906 Visicorder to chart the heartbeat of a Worthington Tripower diesel engine. These Tripower (oil fuel, dual fuel, or spark ignition gas) engines have a fourteen inch bore, an eighteen inch stroke, and develop more than 265 h.p. per cylinder at 450 RPM.

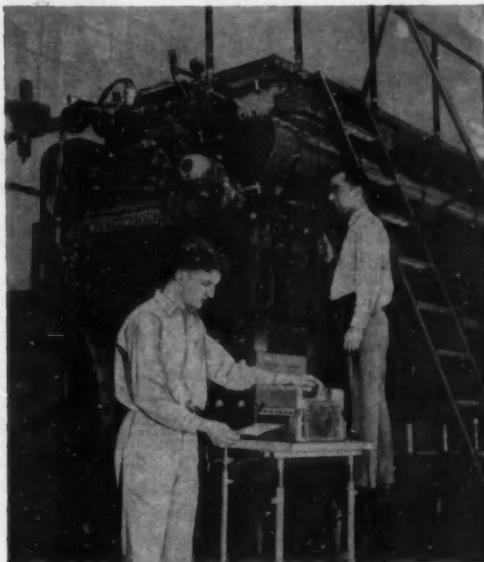
The Visicorder used in these tests makes a direct, instantly-readable record of the pressure variations in the exhaust manifold, cylinder, and intake manifold to determine optimum valve

timing and engine configuration. The Visicorder also produces a permanent record of strain gauge measurements taken on the frame and other critical engine parts.

For the manifold and cylinder pressures, strain gauge pressure transducers and a strain gauge amplifier were used. For the valve lift patterns, a linear potentiometer powered with a small battery was connected directly to the Visicorder.

Analysis of these data has led to changes in the Tripower engine for best performance.

## in diesel engine research



*Ted Dupler (left) and John McAllister, Worthington Engine Research Engineers, measure intake manifold, cylinder, and exhaust manifold pressures and valve stroke on a Tripower with a Honeywell 906 Visicorder.*

The Honeywell Visicorder is the pioneer and unquestioned leader in the field of high-frequency, high-sensitivity direct recording oscillography. In research, development and product testing everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

The new Model 906A Visicorder, now available in 8- and 14-channel models, produces longitudinal grid lines simultaneously with the dynamic traces, time lines, and trace identification by means of new accessory units.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

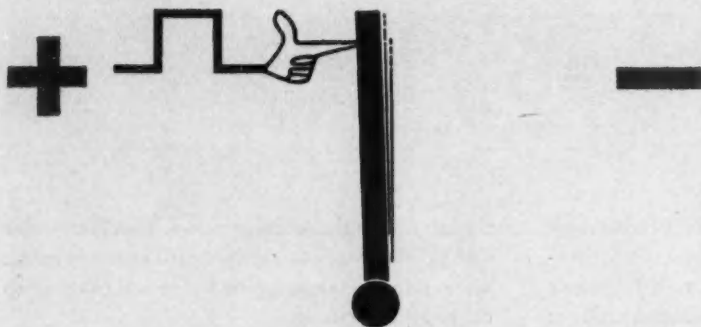
**Reference Data:** Write for Visicorder Bulletin  
Minneapolis-Honeywell Regulator Co.,  
Industrial Products Group, Heiland Division  
5200 E. Evans Ave., Denver 22, Colo.

# Honeywell



*Industrial Products Group*

CIRCLE 127 ON READER-SERVICE CARD



## How to trip a relay\*

WITH A WEE PULSE

The technique of operating relays by direct application of pulses is nowhere near as widely used as (we think) it should be. This method lets you keep relay energy consumption and power supply drain down to a bare minimum — particularly if bi-stable polar relays are used. When you combine pulse operation with magnetic latching, no continuous coil current is needed to keep the relay contacts closed. Of course we have an ax to grind in that there are now no less than six\* series of Sigma polarized, magnetic latching (Form Z) relays which can operate on single pulses. The newest of these is the subminiature Series 32 — which, when operated in this power-pinching way, could be just what you've been looking for.



Series 32

Here are some of the "high spots" in the technique of transferring the armature from one contact to the other with minimum energy. Ideally, the armature should arrive at the center of the air gap with zero velocity, whereupon the magnetic field can take over. A current pulse that starts out at trip value and decreases linearly to zero as the armature reaches the midpoint could do this (fig. 1), but the inductive relay coil makes such a pulse circuit impossible.

\*Sigma Series 6, 7, 32, 61, 72 & 73

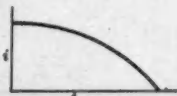


Fig. 1

However, similar waveforms can be approximated by a capacitor-stored pulse discharged into the relay coil. Although there are several fundamentally similar ways of doing this, one circuit (fig. 2) wastes no energy in a resistor and permits the relay to take a round trip operation on a single slug of energy from the source.

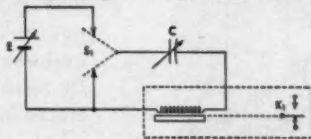


Fig. 2

As you get deeper into this business, it turns out that at least two quantities must be known to apply this method: the "pulse constant" in microjoules per mw. of relay sensitivity, and the "matching constant" in microseconds. A technical paper discussing all of the foregoing in some detail (presented at the recent NARM Conference), pulse application data, Series 32 bulletin, etc. are available on request. Ask for the special "PulsePacket", hand-somely bound in a manilla envelope.



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# SIGMA

SIGMA INSTRUMENTS, INC.  
69 Pearl St., So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO. (since 1939)

CIRCLE 128 ON READER-SERVICE CARD

CONTROL ENGINEERING

## NEW PRODUCTS

time-dependent parameter such as frequency. Three interchangeable potentiometers, with ranges of 20, 40, and 80 db, are available. Writing speed is adjustable up to 20 in. per sec. Four chart speeds, between 2.5 and 75 in. per min, are provided, but an optional interchangeable motor will reduce these speeds by a factor of 60 for long-term studies (up to 480 hrs). With a linear potentiometer, also available as an accessory, the instrument becomes a general-purpose dc recorder having an adjustable zero level and a 0.8-volt full-scale sensitivity.—General Radio Co., West Concord, Mass.

Circle No. 211 on reply card

## PRIMARY ELEMENTS & TRANSDUCERS



### GYRO INTEGRATING

Mass flow of both liquids and gases can be accurately measured and integrated by the new GE Type LB flowmeter pictured above. Completely self-contained, the device includes four basic components:

- a flow sensor that operates on the well-known angular momentum principle and produces a torque proportional to mass flow,
- a gyro that accurately measures the torque produced by the flow sensor and precesses at a proportional rate,
- a cyclometer register, geared to the precession axis of the gyro, that indicates total flow in pounds, and
- a contact device that can be used to actuate auxiliary equipment. Operating the gyro rotor and impeller motor from the same source eliminates the need for a regulated power supply. The meter will handle liquid flows

# FROM LAGRANGIAN TO LIFT-OFF

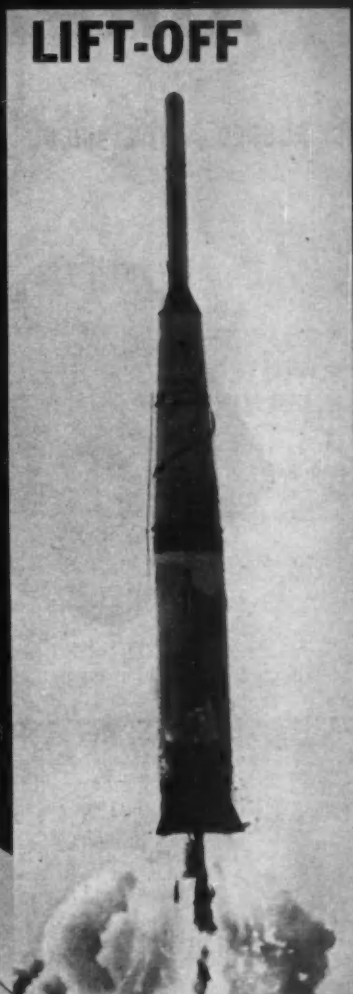
Sometimes forgotten during the thundering ascent of a space probe rocket are months of meticulous analysis, engineering and planning. The staff of Space Technology Laboratories is now engaged in a broad program of space research for the Air Force, the National Aeronautics and Space Administration and the Advanced Research Projects Agency under the direction of the Air Force Ballistic Missile Division. For space probe projects STL provides the total concept approach, including preliminary analysis, sub-system development, design, fabrication, testing, launch operations and data evaluation. The total task requires subtle original analysis in many fields as well as sound technical management.

The STL technical staff brings to this space research the talents, which have provided system engineering and technical direction since 1954 to the Air Force Ballistic Missile Program. Major missile systems currently in this program are Atlas, Titan, Thor and Minuteman.

The scope of STL's responsibilities offers creative engineers, physicists and mathematicians unusual opportunities to see their ideas tested in working hardware. Inquiries are invited regarding staff openings in the areas of Advanced Systems Analysis, Rocket Propulsion, Space Flight Mechanics, Dynamics, Structural Analysis, and Aerodynamics.

**Space Technology Laboratories, Inc.**

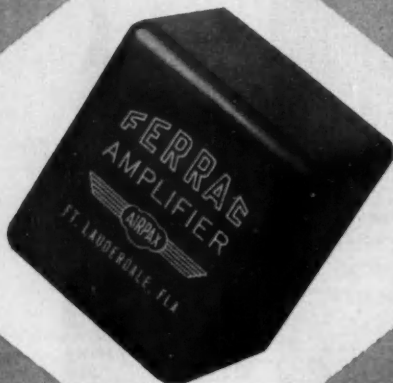
P. O. Box 95004, Los Angeles 45, California



$$L = \frac{m}{2} (\dot{r}^2 + r^2 \dot{\theta}^2 + r^2 \sin^2 \theta \dot{\phi}^2) + \frac{GMm}{r}$$

# NEW MOLDED MAGNETIC AMPLIFIERS BY AIRPAX

THE MOST RUGGED, ACTIVE CIRCUIT ELEMENT YET DEvised!



FASTER RESPONSE, WIDER DYNAMIC RANGE

**Life Unlimited!**  
This smaller, lighter, molded unit offers the systems engineer a component which is nearly indestructible both electrically and mechanically. Complete common mode rejection is an inherent feature. In this new line of FERRAC amplifiers, the conventional plug-in arrangement has been replaced by a bolt-down unit with a low center of gravity eliminating the need for a mounting clamp.



SEMINOLE DIVISION

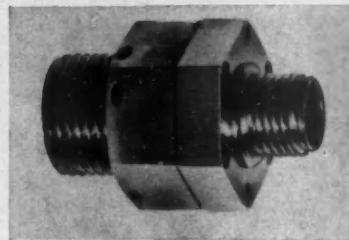
FORT LAUDERDALE, FLA.

CIRCLE 130 ON READER-SERVICE CARD

## NEW PRODUCTS

up to 240,000 pph and gas flows to 40,000 pph, depending on pressure. Makers claim that accuracy is within 1 percent and repeatability within  $\frac{1}{4}$  percent from 10 to 133 percent of the nominal flow rating. Unit draws only 55 watts from a 120-volt, 60-cycle line.—General Electric Co., Schenectady, N. Y.

Circle No. 212 on reply card



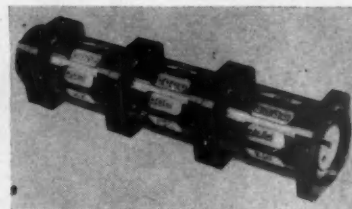
### OIL-DAMPED PICKUP

Oil-damping of this P285TC miniature pressure transducer enables it to withstand the violent pressure transients generated in shock tubes or transmitted from firing chambers. At the same time, it retains the high natural frequency of undamped miniature flush-diaphragm instruments.

#### Characteristics:

Range: 0-50 to 0-1,000 psi  
Output: approximately 28 mv full scale open circuit at 7 volts excitation (ac or dc)  
Linearity: within 1 percent  
Case length:  $\frac{49}{64}$  in.  
Width across flats: 1.0 in.  
Weight: approximately 3 oz  
—Statham Instruments, Inc., Los Angeles, Calif.

Circle No. 213 on reply card



### NEEDS NO RELAYS

A 500-ma output circuit enables this Model AP-124 bi-directional shaft encoder to directly pulse data processing equipment, without an intermediate relay matrix. A second output, of  $\frac{1}{4}$  to 1 ma, is available for neon lamps or other display devices. Unit shown consists of three decades, but any number of decades can be pro-

## SWARTWOUT Autronic® INSTRUMENTATION



### eliminates trouble at the transmitter - - - where trouble is really TROUBLE

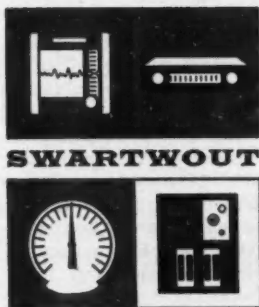
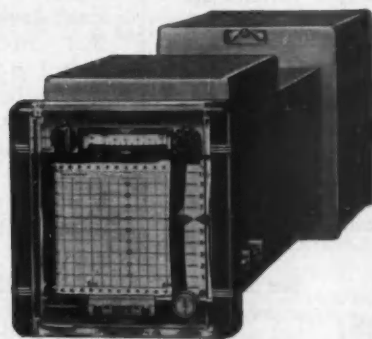
The differential transformer, heart of the transmitter, is so dependable in operation that Swartwout guarantees its performance unconditionally for life. What more could be said?

Added to the control advantages of the fully electronic loop is the dependability of the exclusive AC-DC system. It offers the best of everything: AC in sensory and amplification circuits; DC in the control output signal. It is tested, proven and praised by users in all fields.

For good reasons, the trend is definitely Autronic . . . and the full facts are available to you in a new series of four bulletins. Request Bulletin Series A-801.

No instrument transmitter, either developed or on the horizon, matches Swartwout in simplicity . . . reliability . . . or performance.

Swartwout offers utmost reliability where it counts most: out on the process line. Without tubes or transistors . . . electrical adjustments, slide wires or involved circuitry . . . without orifices to plug or magnetic amplifiers . . . the Autronic transmitter has virtually nothing that can fail. No tinkering; no tampering; no replacements; no trouble.



... world leader in  
electronic process  
instrumentation

**THE SWARTWOUT COMPANY**  
18511 EUCLID AVENUE,  
CLEVELAND 12, OHIO

D.A. 1080

# ROTARY multi-pole multi-circuit SWITCHES



Max.  
dia. 2"  
mounts  
in 1/2" hole

TYPE

## JL



ACTUAL  
SIZE

TYPE

## MA-12

### FOR ELECTRIC CIRCUITS:

TYPE JL rotary switch is a low-power switch with an electrical rating of 5 amperes, 125 volts a-c. A maximum of eight positions — up to ten sections — are controlled by a single knob. This type permits unlimited rotation in both directions but can be limited to any number up to eight positions by two stop screws. It is designed for single-hole panel mounting. Meets MIL-S-21604 and BuShips Drawing Number 9000-S6202-74422. Write for free Bulletin 101-A containing comprehensive data.

### FOR ELECTRONIC CIRCUITS:

TYPE MA-12 is a miniature rotary switch with an electrical rating of 3 amperes, 115 volts a-c. A maximum of six contact positions — up to five sections — are controlled by a single knob mounted on a 1/4" shaft. Rotation can be unlimited in both directions but can be limited from two to twelve positions by two stop screws. This type rotary switch mounts in 3/4" square, single-hole panel mounting. Designed to meet MIL-S-3786.

AT  
WESCON



## ESCO of WEYMOUTH

ELECTRO SWITCH CORPORATION

167 King Avenue, Weymouth 88, Massachusetts

CIRCLE 132 ON READER-SERVICE CARD

CONTROL ENGINEERING

## NEW PRODUCTS

vided. Standard 10:1 gearing links the brushes of each decade, and a solenoid furnishes both the power and intelligence to actuate the next decade. Maximum slewing speed is 1500 rpm, each revolution providing 10 counts. An internal switching arrangement prevents ambiguity in the readout which has an error of less than 1/4 the least significant digit.—United Precisioners, Inc., Calabasas, Calif.

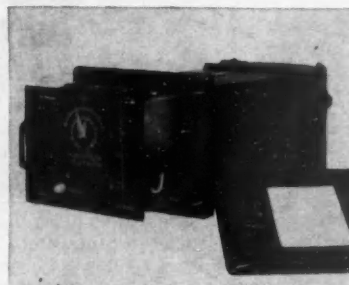
Circle No. 214 on reply card

### PLUS...

(215) A new chamber-type unbonded strain gage pressure pickup, by the Transducer Div. of Consolidated Electrodynamics Corp., Pasadena, Calif., retains its accuracy at pressures up to 10,000 psi. . . . (216) Ohio Semiconductors, Inc., Columbus, Ohio, has developed a new Hall-effect device featuring high gauss sensitivity and wide-range temperature stability.

Circle No. 215 or 216 on reply card

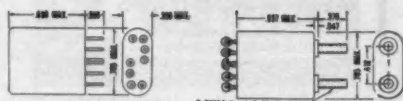
## CONTROLLERS, SWITCHES & RELAYS



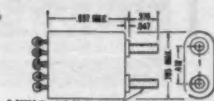
### SPECIAL PURPOSE

The Model 760-W Maximizer represents a special version of the Quarie optimal-mode controller introduced three years ago. Whereas earlier models were designed to control at any slope on the process curve, the 760-W controls only at zero slope. Not a peak-seeking device but a true zero-slope controller, it will maximize or minimize a given process condition. Typical applications include: maximizing dollar gain across a distillation column; controlling solvent flow in a catalytic reaction to obtain maximum product; minimizing fuel costs in a furnace or boiler; or holding a mini-

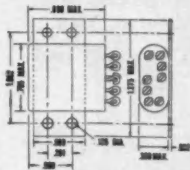
CIRCLE 133 ON READER-SERVICE CARD →



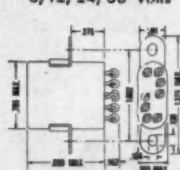
**SC11D**  
6, 12, 24, 36 Volts



**SC11DK**  
6, 12, 24, 36 Volts



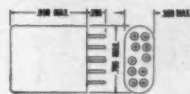
**SC11DB**  
6, 12, 24, 36 Volts



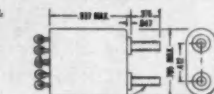
**SC11DA**  
6, 12, 24, 36 Volts

**SC**

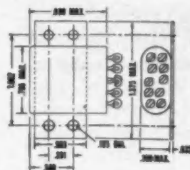
**2 TYPES • 4 MOUNTINGS • 4 VOLTAGES**



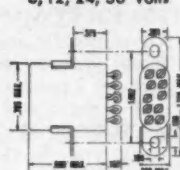
**SL11D**  
6, 12, 24, 36 Volts



**SL11DK**  
6, 12, 24, 36 Volts



**SL11DB**  
6, 12, 24, 36 Volts



**SL11DA**  
6, 12, 24, 36 Volts

**SL**



*Off the shelf delivery* FROM YOUR P & B DISTRIBUTOR

## **32** STANDARD P & B CRYSTAL CASE RELAYS

Prototype or small-production-run quantities of P&B's micro-miniature relays are now available from your local electronic parts distributor. Choose from 2 types, 4 mountings, 4 coil voltages—32 models in all.

P&B's dual coil, permanent magnet, crystal case relays remain operative under 100g shock, 30g to 2000 cps vibration. Modern White Room production facilities assure

highest possible reliability.

The SC conforms to standard dimensions and circuitry, and can replace ordinary relays of the same size.

The SL, a latching relay, utilizes the dual-coil, permanent magnet principle to provide a highly efficient, tenacious latch, assuring high contact pressure.

**Order today from your local electronics parts distributor.**

### **SC and SL SPECIFICATIONS:**

**Shock:** 100g for 11 millise.

**Vibration:** 30g from 55 to 2000 cps  
.195" max. excursions from 10 to 55 cps

**Ambient Temperature Range:**  
-65°C. to +125°C.

**Contact Arrangement:** dpdt

**Contact Load:** 2 amps at 30 vdc  
1 amp at 115 vac, 60 cycle

### **Sensitivity:**

SL—230 milliwatts at 25°C. with  
630 ohm coil

SC—260 milliwatts at 25°C. with  
550 ohm coil



**POTTER & BRUMFIELD**

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

# Typical Control Functions solved by AIR CIRCUITRY



## Westinghouse Multi-Position Cylinder

The Westinghouse Air Brake Company's complete line of AIR CIRCUITRY components contains a wide variety of pneumatic positioners to handle almost all of your force and positioning requirements.

No longer is pneumatic positioning limited to a single or double acting cylinder. Remotely controlled by directional and/or pressure control valves, both variable and fixed force and positioning is possible. Along with all the advantages of air, these devices are easily maintained and serviced. Uncomplicated and rugged, pneumatic positioners may be the answer to your control problems.

**Typical Applications**—The illustrated positioners have been used in almost every field of industry today. These positioners can:

clamp	punch	act	convey	push
rotate	lock	form	band	blank
index	brach	crimp	cushion	pull
hold	squeeze	twist	stretch	object
feed	shear	raise	brake	move
piece	lower	press	turn	coil

If you have a positioning problem, let us know about it. It can probably be solved with AIR CIRCUITRY. For more information, ask for our catalog on Positioners.

## What is AIR CIRCUITRY?

This is the Westinghouse term for application of pneumatic control systems to industrial production operations. Safe, economical, precise AIR CIRCUITRY is now being used to solve the most rigorous and complex control problems in industry. Westinghouse Air Brake has pioneered the application and development of air control for more than 80 years. Today our engineers can design an air circuit which will help you boost production and cut costs in your plant or shop.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor



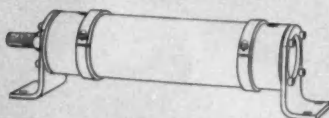
**WESTINGHOUSE AIR BRAKE COMPANY**

INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

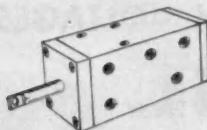
CIRCLE 134 ON READER-SERVICE CARD

CONTROL ENGINEERING

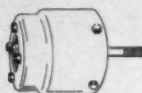
134



**1. ONE AND TWO STATION POSITIONING**—Single and double acting cylinders can perform all types of force and positioning functions. The Westinghouse line of cylinders includes diameters from 1" to 10"; strokes to suit application; single and double end; foot, swivel, flange and trunnion mounts.



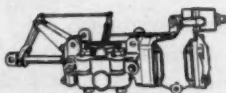
**2. MULTI-STATION POSITIONING**—Controlled by an associated directional valve, these cylinders attain 3, 4, 5 and 7 fixed positions of stroke. Three position cylinders are available in 2", 3", 4", 5" and 6" diameters. Strokes may be obtained to suit application.



**3. VARIABLE FORCE AND POSITIONING**—Diaphragm type cylinders are controlled by manually or mechanically operated pressure control valves to achieve a variable force or position of the rod. Various diaphragm areas and strokes available.



**4. INFINITE POSITIONING-LIGHT**—The actuator positioner has an infinite number of positions, governed by the amount of air pressure acting on its spring opposed diaphragm. Remotely operated pressure control valves dictate the position of the operated lever. This device has a low force rating.

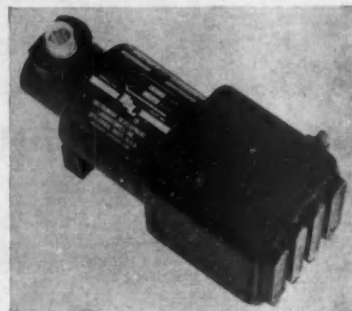


**5. INFINITE POSITIONING-HEAVY**—The Westinghouse PNEUDYNE® Positioner can position accurately, independent of the opposing force, up to its power capacity. The power capacity is determined by piston size and supply pressure. Remotely controlled by pressure control valves, this device maintains its position throughout changes in the opposing force.

## NEW PRODUCTS

mum or maximum conductivity or viscosity. It permits simplified computer control on a unit process basis. —Quarie Controllers, Canton, Mass.

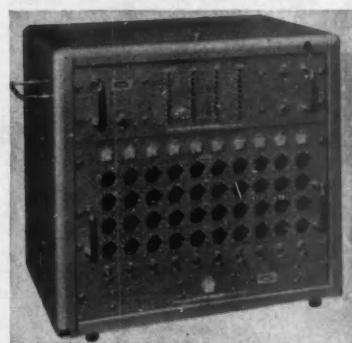
Circle No. 217 on reply card



## FM/FM COMMUTATOR

Developed for use in fm/fm telemetering systems, this new commutator includes 2 poles with 30 contacts each and 2 poles with 60 contacts each. All contacts are of the make-before-break type. With all 180 data channels available at hermetically sealed connectors, the unit can be externally wired for any desired sequence. A 28-volt dc ungoverned motor provides the drive. Guaranteed for better than 250 hours operation, the unit has an overall length of 6½ in. and weighs 3 lb.—Instrument Development Laboratories, Inc., Attleboro, Mass.

Circle No. 218 on reply card

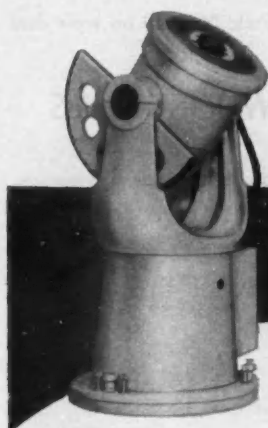


## SEQUENCE PROGRAMMER

Photo above shows a new sequential program controller, the Model 12A4P-10, which provides up to 10 successive relay closures at the completion of cumulative preset counts. This unit uses a four-decade indicating counter and will handle either time-pulse or shaft position input data. Cost of the

**Reeves**  
INSTRUMENT CORPORATION

**first in today's front page developments**



**GYRO TEST TABLE (Model RD)**  
Positioning data accuracy guaranteed to 2 sec. arc. Complete electronics for testing any type of inertial gyro or complete inertial reference packages.



**GYRO TEST CONSOLE (GTS-1001C)** First fully equipped COMPLETE test facility for testing of single axis integrating gyros. Can also be adapted for testing precision floated accelerometers.



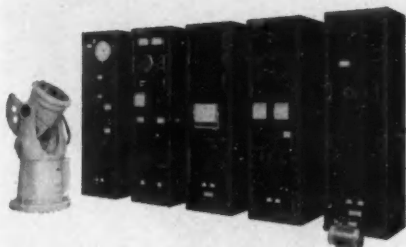
**DIFFERENTIAL WATTMETER** High precision test detection of extremely small power consumption differentials in gyro spin motors and other types of rotating components.

## GYRO AND GYRO SYSTEM TEST EQUIPMENT for today's front page missile programs

Reeves' research and development in the field of precision gyros has always paced the industry, resulting in over ten years of high level gyro production, based on exacting reliability standards subject to the most exhaustive quality control. Today's gyros and gyro systems demand high precision test equipment far beyond the capabilities of commercially available instruments. To meet this need, Reeves has specified, designed, and built test equipment capable of meeting the most stringent requirements — not only for today, but for the foreseeable future as well.

Through the years, this test equipment has been refined and packaged to the point where we now can present with confidence the most accurate and comprehensive line of gyro test equipment available.

**superbly precise . . . fast, simplified operation . . . maximum reliability**



**TYPICAL ELECTRONICS GROUP** for inertial reference package system test. All Reeves equipment offers Laboratory accuracy with production line practicality.

This equipment has numerous practical advantages for producers and users of gyros and gyro systems. Exceptional accuracy and flexibility permit rapid testing of today's most advanced gyros and inertial reference packages, as well as tomorrow's even more advanced designs.

Ease and reliability of operation, along with intelligent human engineering, allow for rapid training of equipment operators. Production quantities can be tested with laboratory precision.

Simplified maintenance and service assure against costly down-time.

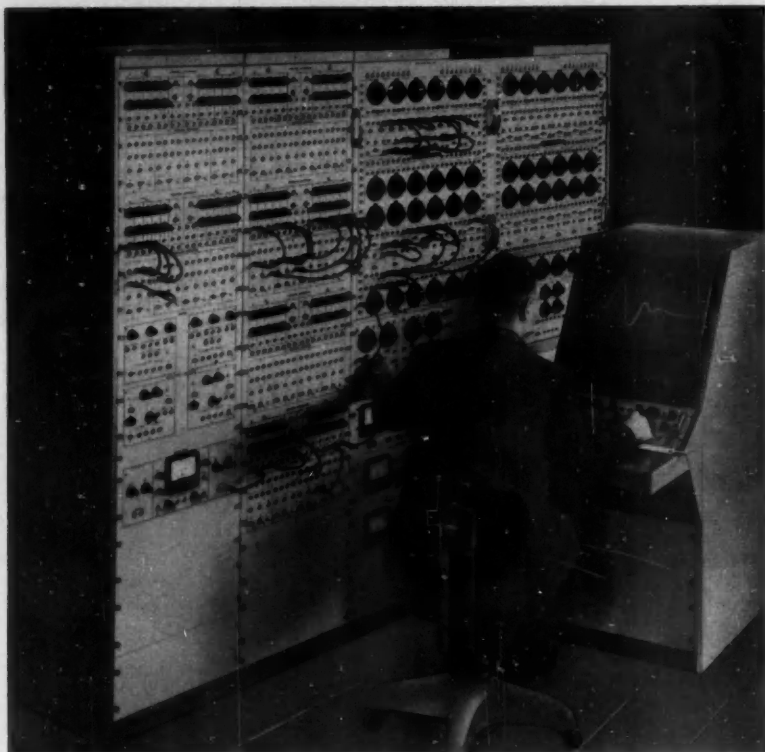
Your inquiries are invited.

See our display  
at **WESCON**  
Booths 3303-3305

**REEVES INSTRUMENT CORPORATION**

A Subsidiary of Dynamics Corporation of America—Roosevelt Field, Garden City, New York

**Reeves**  
INSTRUMENT CORPORATION



## THE ONLY AVAILABLE STATISTICAL-ANALOG COMPUTER

The GPS Statistical-Analog Computer is without a doubt the most advanced in the state of the art, and is in every sense of the meaning...

- ▶ A TRULY HIGH-SPEED, HIGH CONFIDENCE-LEVEL COMPUTER
- ▶ A TREMENDOUS TIME AND MANPOWER SAVER\*
- ▶ UNRIVALLED OR UNEQUALLED IN PERFORMANCE
- ▶ VERSATILE IN APPLICATION

The basic GPS computer is a compressed time-scale analog computer which operates 3000 times faster than real time. A solution is generated and repeated automatically at rates up to 50 times/sec. As many as 3000 independent runs or solutions can be statistically evaluated in a minute of time.

With the GPS computer you eliminate the drudgery of routine analyses, the endless footage of data recording, and the subsequent tedious data reduction.

Because of the new design principle and inherent versatility, the GPS com-

puter provides immediate computation of the statistical and dynamic characteristics of:

- Missile guidance and control systems
- Radar systems in general
- Process and quality control
- Flight control

\*An analysis of a missile miss-distance was conducted at the GPS COMPUTER CENTER by the research laboratory of a large aircraft firm. Their report stated that, "25 times as much data (with higher confidence-level) was collected in one week on the GPS computer as was collected and analyzed in 4 months time on a slow-speed computer"

Our engineers are ready to assist you.  
For further details please write or call Dept 21

**GPS INSTRUMENT CO., Inc.**

180 NEEDHAM STREET • NEWTON 64, MASS.

CIRCLE 136 ON READER-SERVICE CARD

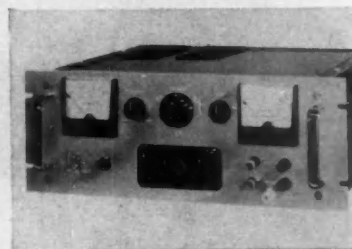
CONTROL ENGINEERING

## NEW PRODUCTS

unit less pickups and special preamplifiers is below \$1,500.—The Redford Corp., Lake Luzerne, N. Y.

Circle No. 219 on reply card

## POWER SUPPLIES



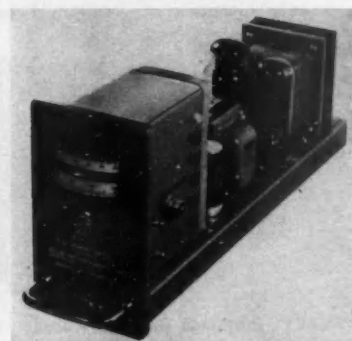
### SHORT RECOVERY TIME

Priced at \$610, the Model ME36-5EM power supply contains a magnetic line voltage regulator and a transistorized regulator circuit. The first protects the transistors against excessive power dissipation when the output is shorted, and the latter provides low recovery time with overshoot less than 1 percent of the voltage setting. Output voltage is 0 to 36 volts dc at 0 to 5 amp, and is vernier controlled.

#### Characteristics:

Ripple: less than 1 mv, rms  
Line regulation: 0.05 percent  
Load regulation: 0.1 percent  
Size: fits 19-in. relay rack  
—Mid-eastern Electronics, Inc., Springfield, N. J.

Circle No. 220 on reply card



### BRAND NEW LINE

This plug-in module, designed for individual or multiple mounting in panels and relay racks, is part of a brand new series of highly regulated dc supplies. Both vacuum tube and transistorized models are available

# NOW...FROM NORTH ELECTRIC 4 & 6 POLE RELAYS FOR MILITARY AND INDUSTRIAL APPLICATIONS



## North Electric Buys RCA Relay Designs, Equipment

Announcement was made today that North Electric Company has purchased from the Radio Corporation of America all designs, manufacturing equipment, machinery and tooling used in the manufacture of their line of relays.

Included in the purchase were machinery, tooling and design for 2, 4, and 6 pole hermetically sealed sub-miniature relays and design data for micro-miniature types not heretofore produced by RCA or North Electric. The purchase price was not disclosed.

Commenting on the acquisition, William Tucker, president of North, indicated that this is an important step in a program intended to place North in a stronger position in the relay field. Concurrently, new type relays which have been developed in the North laboratories are being released for manufacture. These, together with the RCA relays, should add several million dollars in sales in 1959.

The program includes plans for expanding the North Research and Development facilities for the development of additional types that will give North a pre-eminent position in the relay market.

Machinery and equipment is now being removed from RCA's plants in Camden, N. J., and is expected to be set up and operating in the Galion plant within 60 days.

Reprinted from:  
the Galion Inquirer,  
Feb. 19, 1959

Subminiaturized, ruggedized, hermetically sealed relays—designed for superior performance and maximum reliability in missile and airborne applications, these relays meet and exceed the stringent specifications of MIL-R-5757A, B, C and MIL-R-25018 (USAF).

4 and 6 PDT relays available for AC, DC and Dry Circuit use.

For full spec data and complete listing of types available, write—

**INDUSTRIAL DIVISION**  
**NORTH ELECTRIC COMPANY**  
298 S. MARKET, STREET, GALION, OHIO



## NOW... first electrostatic generators for industrial use that can give several kilowatts at up to 600,000 volts dc

The complete line of "Sames" electrostatic generators—the first practical industrial electrostatic power supplies—are now available in the U.S. from Sorensen & Company. They supply from 50 to 600 kilovolts dc at substantial amounts of power (2400 watts for the 600 kv model).

The Sames generators (so-called from their manufacturer, Societe Anonyme de Machines Electrostatiques, Grenoble, France) are extremely compact and safe compared to transformer-rectifier-filter-type supplies in similar kilovolt ranges. The electrostatic generators are available in highly stabilized models supplying 50, 100, 150 and 600 kilovolts that are particularly suitable for electron-microscopy and many critical nuclear physics applications. Medium stability models with outputs of 50, 80, 100, 140, 150, 250, 300, and 600 kilovolts, have found wide application in Europe for testing cable insulation, alternator windings and other dielectrics, electrostatic flocking, painting and particle precipitation, electron and nuclear particle accelerators and similar applications.

Write for complete details on Sames electrostatic generators to Sorensen & Company, Richards Avenue, South Norwalk, Conn. **8.38**

## HIGH VOLTAGE



**SAMES**  
600-kilovolt  
electrostatic  
generator  
with control  
panel and  
electronic  
unit.

**SORENSEN & COMPANY, INC.**  
Richards Avenue, South Norwalk, Conn.

WIDEST LINE OF CONTROLLED-POWER  
EQUIPMENT FOR RESEARCH AND INDUSTRY

In Europe, contact Sorensen-Ardag, Zurich, Switzerland.  
In Western Canada, ARVA. In Eastern Canada, Bayly  
Engineering, Ltd. In Mexico, Electro Labs, S.A., Mexico City.



**CIRCLE 138 ON READER-SERVICE CARD**

## NEW PRODUCTS

with a wide variety of output currents and voltages. Line and load regulation on all models is within 0.25 percent; ripple, less than 5 mv, rms.—Plug-In Instruments, Inc., Nashville, Tenn.

**Circle No. 221 on reply card**

### HIGH-VOLTAGE SUPPLY

Suitable for nuclear research, experimental, and industrial applications, the Model PS 25-200-1 dc power supply will deliver 200 ma at 25 Kv, operating from a 208 volts, 60-cycle, 3-phase line. Multiplier resistors permit a 100- $\mu$ a full scale meter to indicate output voltage. Unit is housed in a steel cabinet measuring 21 by 17½ by 18 in. high, with a hand hole in the top cover to facilitate replacement of the rectifier tubes.—Del Electronics Corp., Mount Vernon, N. Y.

**Circle No. 222 on reply card**

### PLUS. . .

(223) A series of 10 new low-voltage, transistor-regulated power supplies, with outputs ranging from 10 to 50 volts dc, was recently announced by Power Sources, Inc., Burlington, Mass. . . . (224) Arkay Engineering, Inc., Santa Monica, Calif., offers the Series RK200 encapsulated, solid-state frequency standards with pulse or square wave outputs.

**Circle 223 or 224  
on reply card**

## ACTUATORS & FINAL CONTROL ELEMENTS



### LIGHTWEIGHT MUSCLE

Driven by a 26-volt dc bi-directional motor, this new lightweight actuator will move a load in excess of 100 lb. Yet it weighs only 0.8 lb, measures 6½ in. long, and uses a single gear



## GROUND SUPPORT EQUIPMENT

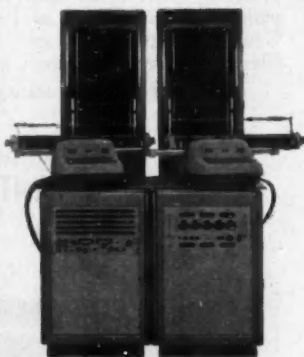
**A Proven Kearfott Capability** – Kearfott's prominence in the design and production of ground support equipment is a result of 15 years' experience in producing precision servo systems, computers, gyro reference systems and inertial guidance equipment. Kearfott test equipment is designed on modular principles which increase flexibility and economy and eliminate the obsolescence factor since modules can be readily modified or replaced. Modules are designed to be compatible with one another, thus providing test capabilities for a wide variety of applications.



Inertial Guidance System Test Console

**FIELD-TYPE TEST EQUIPMENT:** Modularized, self-contained unit that provides all power and signal voltages to operate, test or troubleshoot a gyro. All inputs to and outputs from the gyro are accessible at convenient jacks where connections to measuring equipment can be made, thereby enabling operator to evaluate gyro performance completely. Modules are slide-mounted for ready access if repair, modification or product improvement replacement are required. This portable equipment performs these basic tests:

*Insulation resistance • Warm-up time • Torquer scale factor measurement  
Gyro transfer function • Free drift • Gimbal offset drift • Continuity  
Signal Generator Null • Phasing • Gyro drift • Fixed torque restraint*



Scalog 200-Scan  
Alarm Logging System



Floated Gyro Test Console

**GENERAL PURPOSE DATA PROCESSING:** This data handling system provides a reliable, precise means of monitoring, logging and performing an alarm function of up to 200 separate temperature, pressure, liquid level or flow transmitters. Manual controls are provided for scanning rates, automatic or manual logging, data input relating to operator, time, day, run number and type of run. 200 numbered lights, corresponding to specific points being maintained, provide a visual "off normal" display for operator's warning. This system has growth built in and can be expanded in capacity to 1024 points and in scanning rate to 2000 points per second.

*Write for complete information on Kearfott's ground support equipment.*

**Engineers:** Kearfott offers challenging opportunities in advanced component and system development.



VTVM-PSVM



High-Speed  
Precise Angle  
Indicator Module



Automatic  
Ohmmeter  
Module

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# NEW BENDIX DRIVER TRANSISTORS



AUDIO AMPLIFIER (CLASS A OR B) • AUDIO OSCILLATOR • POWER SWITCH  
TRANSISTOR DRIVER • SERVO CONTROL • RELAY DRIVER • MOTOR CONTROL

Slated to be the "workhorse of the transistor industry", this new Bendix series consists of three models—each with a different voltage rating and each in high-volume production.

Contained in the JEDEC TO-9 package, this tiny transistor dissipates 400 mW of power at 25°C and 67 mW at 75°C. The higher voltage rating and high current gain are combined with more linear current gain characteristics to enable switching applications and lower distortion output. Featuring low saturation resistance, the typical values are 1 ohm measured at 100 MA. The 2N1008 series has a minimum current gain of 40 and a maximum of 150.

West Coast Sales Office: 117 E. Providencia Avenue, Burbank, California

Midwest Sales Office: 4104 N. Harlem Avenue, Chicago 34, Illinois

New England Sales Office: 4 Lloyd Road, Tewksbury, Massachusetts

Export Sales Office: Bendix International Division, 205 E. 42nd Street, New York 17, New York  
Canadian Affiliate: Computing Devices of Canada, Ltd., P. O. Box 508, Ottawa 4, Ontario, Canada

**Red Bank Division**



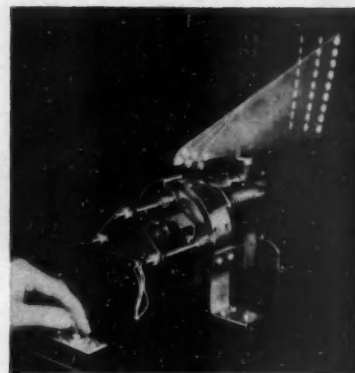
CIRCLE 140 ON READER-SERVICE CARD

CONTROL ENGINEERING

## NEW PRODUCTS

stage. Designed for two-position systems on aircraft and missiles, it features a normal stroke of 3 in. Its motor, powered at all times, is designed to withstand a continuous locked rotor condition. Stall current is less than 1.2 amp.—The Garrett Corp., AiResearch Mfg. Div., Los Angeles, Calif.

Circle No. 225 on reply card

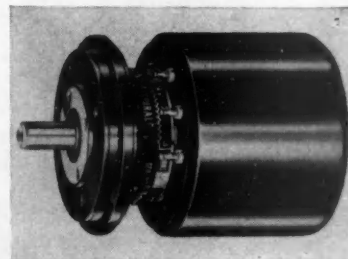


### HOT GAS SERVO

Photo above shows a recently tested hot gas servo that will operate for periods longer than 2 min on dirty solid propellant grain gases. The compact device provides discontinuous or step-type actuation for positioning missile or drone control surfaces. Two, three, or five positions are available. Company believes its total operating period can be as long as 10 min.—General Electric Co., Light Military Electronics Dept., Johnson City, N. Y.

Circle No. 226 on reply card

## COMPONENT PARTS



### ELIMINATES HUNTING

Pictured is one model of the new Spiralpot line which incorporates the following improvements: use of a sin-



GD60 AND  
80 SERIES



GD100  
SERIES



LR20B  
SERIES

**Control  
gases  
safely,  
accurately**

## TO 15,000 PSI AND 50,000 SCFM WITH VICTOR REGULATORS

You get precise regulation of high pressure gases with large flow rates, because Victor employs gas pressure to control the regulating diaphragm. The result is accurate delivery from 5 to 15,000 psi with inlet pressures to 15,000 psi . . . plus ability to obtain flows in excess of 50,000 scfm at maximum inlet and outlet pressures. Chart below shows operating range of standard models.

MODEL NO.	MAX. INLET PSI	MAX. OUTLET PSI	FEATURES	MAX. FLOW SCFM
GD10	3,600	500	Single adjustment regulator control	250
GD30	2,500	2,500	Load & bleed valve control	400
GD31	3,600	3,600	Load & bleed valve control	600
GD61C	2,500	2,500	Load & bleed valve control	170
GD62C	3,600	3,600	Load & bleed valve control	200
GD65	6,000	6,000	Load & bleed valve control	250
GD65C	7,000	7,000	Load & bleed valve control	250
GD80A	5,000	5,000	Load & bleed valve control	500
GD81A	10,000	10,000	Load & bleed valve control	800
GD86R	10,000	10,000	For remote control only	1,200
GD100R	6,000	6,000	For remote control only	20,000
GD100	6,000	6,000	Load & bleed valve control	20,000
GD200	6,000	6,000	Load & bleed valve control	50,000
GD700	7,000	7,000	Single adjustment regulator control; self relieving	250
SR10	3,600	1,000	Small, spring loaded regulator	4
LR20B	7,000	7,000	Spring loaded regulator; self relieving	2
LR20BSS	10,000	10,000	Spring loaded; stainless steel	2
LV10	7,000	7,000	Loader valve control	15
BPR10	7,000	7,000	Back pressure regulator	2

Operating temperature range: -67°F. to +250°F.

**. . . Yours for the asking**  
Take advantage of Victor's long experience with high pressure gas regulation to help solve your special problems involving flow rates, delivery pressures, corrosive fluids and temperature compensation. Write, wire or phone us today. No obligation.

All models listed are field proved. Most are designed for panel mounting or remote control. They regulate all non-corrosive gases, including oxygen. Stainless steel models available for corrosive gases and pressures above 10,000 psi. For complete specifications, write for Victor High Pressure Regulator sheets.

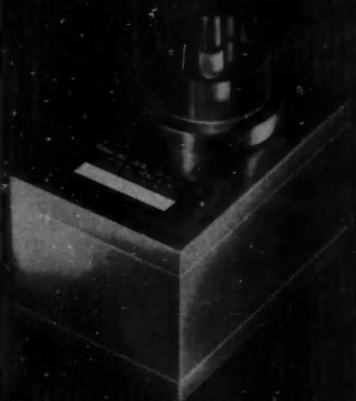
**VICTOR**  
for regulators

**VICTOR EQUIPMENT COMPANY** MISSILE DIVISION  
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J. C. Menzies & Co., Wholly-Owned Subsidiary

CIRCLE 141 ON READER-SERVICE CARD

## VIBRATING CAPACITOR



A vibrating-reed type capacitance modulator for use in measuring currents as low as  $10^{-16}$  amperes.

Long term stability for process control. Drift  $\pm 0.2$  millivolts per day, non-cumulative.

Write for  
Catalog 523.



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INCORPORATED  
ARNOLD**

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SOUTH BOSTON 27, MASS.

S/A-15

CIRCLE 142 ON READER-SERVICE CARD  
142 CONTROL ENGINEERING

## NEW PRODUCTS

gle length of resistance wire which is continuously contacted by the wiper to provide infinite resolution; a brush assembly that eliminates the grooving tendency and linearity shifting; and extra rugged stops for high-performance servo applications. Units are rated for a mechanical life of 250,000 to 1 million revolutions depending on input and will withstand 15g shock on any axis.—G. M. Giannini & Co., Pasadena, Calif.

Circle No. 227 on reply card



### BUILT-IN TRANSFORMER

This new Size 11 amplifierless resolver features an integral transformer that simulates a resolver function at maximum coupling. In a typical chain application for angular data transmission, output information may be servoed at either end. A mating end cap, not shown in the photo, simplifies harnessing and speeds maintenance. Accuracy of the unit is within 5 min of arc.—Clifton Precision Products Co., Inc., Upper Darby, Pa.

Circle No. 228 on reply card

### PLUS . . .

(229) The Model CA9 strain gage signal amplifier, offered by Statham Instruments, Inc., Los Angeles, Calif., operates from a 28-volt dc source and supplies its own regulation. . . . (230) The first Size 8 servomotor developed to BuOrd specs is now available from the Avionic Div. of John Oster Mfg. Co., Racine, Wis. . . . (231) Westinghouse Electric Corp., Pittsburgh, Pa., has introduced a new series of light-weight high-power silicon rectifiers with peak-inverse-voltage ratings from 50 to 500 volts.

Circle No. 229, 230 or 231 on reply Card

## TINY TEAMMATE FOR STRAIN GAGES



### STATHAM CA 9 Strain Gage Signal Amplifier

Through the use of modern design techniques, Statham has succeeded in drastically reducing the size and weight of strain gage signal amplifiers. Completely transistorized, the CA 9 is more reliable in adverse environments than larger and heavier amplifiers, and retains the precision needed in current aircraft and space vehicles.

Write for  
Data File CE-601-2.

STATHAM INSTRUMENTS, INC.  
12401 West Olympic Boulevard  
Los Angeles 64, California



CIRCLE 185 ON READER-SERVICE CARD

# АВТОМАТИЧЕСКИЙ ПЕРЕВОД ВЫЧИСЛИТЕЛЬНЫЕ МАШИНЫ СПОСОБСТВУЮТ ИССЛЕДОВА- НИЮ ЯЗЫКОВ



## AUTOMATIC TRANSLATION

### *Computing machines aid language research at Ramo-Wooldridge*

To formulate rules for automatic language translation is an enormously subtle and complex project. Yet significant progress is being made. During the past year of research at Ramo-Wooldridge over 60,000 words of Russian text have been translated and analyzed using an electronic computer. From the beginning several hundred syntactic and semantic rules have been used to remove ambiguities that are otherwise present in "word for word" translation. Our present computer program for automatic translation is a considerable improvement over earlier attempts.

Apart from the question of translation itself, electronic computers are invaluable for language research. The expansion of existing knowledge of the rules of language, through statistical analysis, is made practical by mechanized procedures. A clear symbiosis between linguistics and computer technology has emerged.

Automatic translation research is one of many R-W activities addressed to problems of communication of

scientific information. These problems are increasing at an accelerating pace. In this area, as in others, scientists and engineers find at Ramo-Wooldridge challenging career opportunities in fields important to the advance of human knowledge. *The areas of activity listed below are those in which R-W is now engaged and in which openings also exist:*

- Missile electronics systems
- Advanced radio and wireline communications
- Information processing systems
- Anti-submarine warfare
- Air navigation and traffic control
- Analog and digital computers
- Infrared systems
- Electronic reconnaissance and countermeasures
- Basic and applied physical research

*For a copy of our brochure or other information, write to Mr. Donald L. Pyke.*



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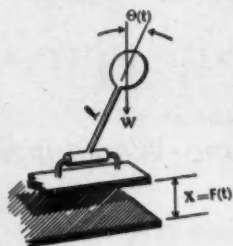
# DONNER Desktop Computers



Predict  
System  
Performance  
*in Minutes*

The small analog computer you see here accurately predicts system performance with extraordinary speed and simplicity.

To illustrate, consider the problem of stabilizing the inverted pendulum below. Solving this problem requires a rigorous study of the stability of solutions to the Mathieu-Hill equation:



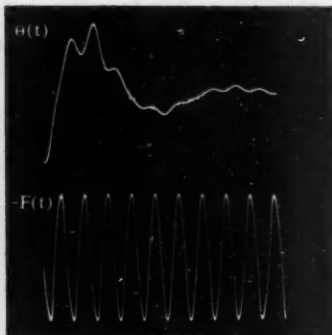
$$\frac{d^2 \theta}{dt^2} = \frac{g}{l} - A F(t)$$

*In just 30 minutes, the computer solved the equations and established definite parameters. An expert mathematician who tackled the same problem at the same time was still working on his second page of calculations! After half a day's work, he had proved only that stability could be achieved—not that it was feasible for this particular pendulum.*

The basic computer used in this problem, including two multipliers, costs less than \$4,000. It can be readily expanded, initially or as your needs grow. Other Donner computers are available for your particular requirements.

By selecting the proper pivot excitation,  $A=F(t)$ , the pendulum can be stabilized. The graph shows the time variations in displacement,  $\theta(t)$  as a function of pivot displacement  $F(t)=A \sin \omega t$ .

For a closer look at methods of studying non-linear systems with the analog computer, including a clear step-by-step analysis of the inverted pendulum, write for Donner Tech Note #2. We'll also send you a brochure on the Model 3400 computer. Please address Dept. 088.



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CIRCLE 144 ON READER-SERVICE CARD

CONTROL ENGINEERING

## WHAT'S NEW

### IMPORTANT MOVES BY KEY PEOPLE

#### Numerical Control Man Heads Pratt & Whitney

Control engineer Jacob J. Jaeger has been elected president of Pratt & Whitney Co., succeeding Edward P. Cillane who becomes assistant to the chairman of the board.

Philadelphia-born Jake Jaeger (Control Personality, CtE, Oct. '56, p.23) was one of the group of pre-war graduate students at MIT who set the foundation for modern servo theory (he was a classmate of Dr. Gordon Brown, who was recently appointed head of Engineering at MIT).

After graduating from Drexel Institute of Technology, Jaeger went to MIT, where he received his masters degree and where he worked from 1934 to 1939 as a research assistant, applying numerics to machine tools. He also contributed to the program that produced the electronic differential analyzer which finally replaced the famous MIT mechanical computer.

He joined Pratt & Whitney in 1940 when the machine tool company was looking for someone to spearhead improvements on its Keller tracer-control systems. By applying servo techniques to the tracer follower, Jaeger developed a line of controls that won broad industry acceptance for the P&W milling machines. In 1946 he was made head of the Experimental Section; in 1949, he became assistant manager of Machinery Div. engineering; in '54, chief engineer; and in '55 vice-president and chief engineer.

Three months ago the control-oriented Jaeger was elected executive vice-president. He was awarded the 1959 Engineering Citation by the American Society of Tool Engineers.



J. J. JAEGER

The servo look in machine tools

See us at  
WESCON,  
Booths 1815  
and 1817

[illegible]

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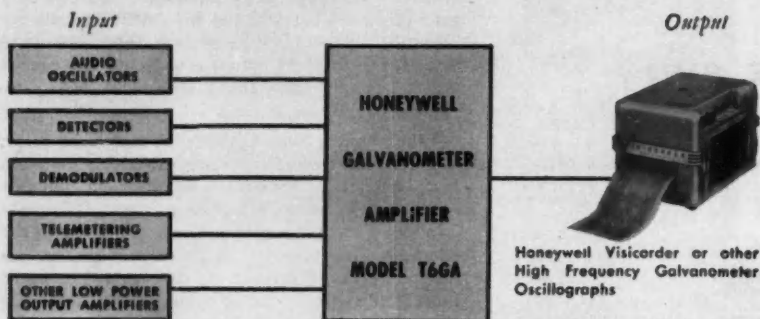


**MINNESOTA MINING AND MANUFACTURING COMPANY**  
... WHERE RESEARCH IS THE KEY TO TOMORROW



## NEW GALVANOMETER AMPLIFIER

### Strengthens Low Power Signals to Drive High Frequency Oscillographs



Galvanometer Amplifier, Model T6GA-1, measures 3½" high, 19" wide, 15½" deep.

#### DESCRIPTIVE DATA

**VOLTAGE GAIN:**  
Adjustable from 0 to 1.0

**OUTPUT (37 OHM LOAD):**  
± 2.4 volts at 65 ma d-c to 8 Kc, limits at ± 100 ma.

**OUTPUT IMPEDANCE:**  
2 Ohms d-c to 10 Kc

**CONTROLS:**  
6 GAIN controls, 1 Power ON-OFF switch

**INPUT IMPEDANCE:** 47 K

**ISOLATION:**  
Individually floating channels for use with ungrounded loads

**NOISE:**  
Less than 3 mv peak-to-peak

**DRIFT:**  
Less than 3 mv/°F

**POWER REQUIREMENTS:**  
115 volts ± 10 volts, 50 to 440 cps, 45 watts

With Honeywell's new Galvanometer Amplifier, Model T6GA-1, high frequency oscillographs can now be operated directly by low power input sources of 1 volt or more. These inputs, some of which are shown in the diagram above, should have output impedances of 10 K or less although higher source impedances can be tolerated. Noise and drift are indistinguishable on the recorded output when the galvanometer-amplifier combination has a maximum sensitivity of 1 inch per volt.

The Model T6GA-1 is a compact, six channel, three stage transistor d-c amplifier with overload protection to eliminate both danger of transistor damage and galvanometer burnout.

Each of the six amplifier channels is isolated from ground by individual floating power supplies. Write for Bulletin B-ET6 to Minneapolis-Honeywell, Boston Division, Dept. 34, 40 Life Street, Boston, Mass.

# Honeywell

WESCON SHOW  
Booth Nos. 2617-2623



*First in Control*

CIRCLE 146 ON READER-SERVICE CARD

146 CONTROL ENGINEERING

## WHAT'S NEW

### Colvin Resigns at CEC

Hugh F. Colvin, vice president of Consolidated Electrodynamics Corp., and one-time president of CEC from 1956 to 1958, resigned as an officer and director of the Pasadena company. He will engage full time as a financial and management consultant in the field of technically oriented companies.

### Geneen Elected to Top Spot at ITT

Harold S. Geneen was elected president of International Telephone & Telegraph Corp., replacing Edmond H. Leavey who retired on July 31. Until recently, Mr. Geneen had been executive vice president, Raytheon Co.

### Fleming in ISA Space Group Post

Lawrence Fleming, first man to measure vibration in a rocket, has been appointed assistant director of the missile space group, Instrument Society of America. A graduate of California Institute of Technology, he is head of test instrument development at Southwestern Industrial Electronics Co.

### Other key moves

Dr. Herbert Kromer has joined Varian Associates as senior research scientist in the central research team. A graduate (PhD in physics) from the University of Göttingen (Germany), he has spent the last nine years conducting research in the semiconductor field. He was last with the German branch of Philips Laboratory, where he headed the semiconductor group.

George H. Wagner has been appointed sales operation manager for the scientific instrument department of Allen B. DuMont Laboratories, Inc. He has been with DuMont since 1952; in his new post he will manage sales, service, and order administration for DuMont oscilloscopes, pulse generators, and associated electronic instruments and accessories.

Vincent E. Ryb has been appointed manager, Titan guidance program at AC Spark Plug, the electronics division of General Motors. Ryb, who began his career with AC in 1935, was formerly manufacturing manager of the division. Donald F. Ayres was named manager of the Thor and the Mace

(Continued on page 150)

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handy prepaid  
post cards will  
bring you detailed  
information

**IMPORTANT: Circle key numbers below and mail before November 1, 1959**

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9	19	29	39	49	59	69	79	89	99	109	119	129	139	149	159	169	179	189	199

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206	216	226	236	246	256	266	276	286	296	306	316	326	336	346	356	366	376	386	396
207	217	227	237	247	257	267	277	287	297	307	317	327	337	347	357	367	377	387	397
208	218	228	238	248	258	268	278	288	298	308	318	328	338	348	358	368	378	388	398
209	219	229	239	249	259	269	279	289	299	309	319	329	339	349	359	369	379	389	399

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201	211	221	231	241	251	261	271	281	291	301	311	321	331	341	351	361	371	381	391
202	212	222	232	242	252	262	272	282	292	302	312	322	332	342	352	362	372	382	392
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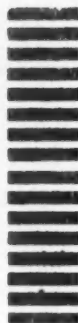
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330 WEST 42nd Street  
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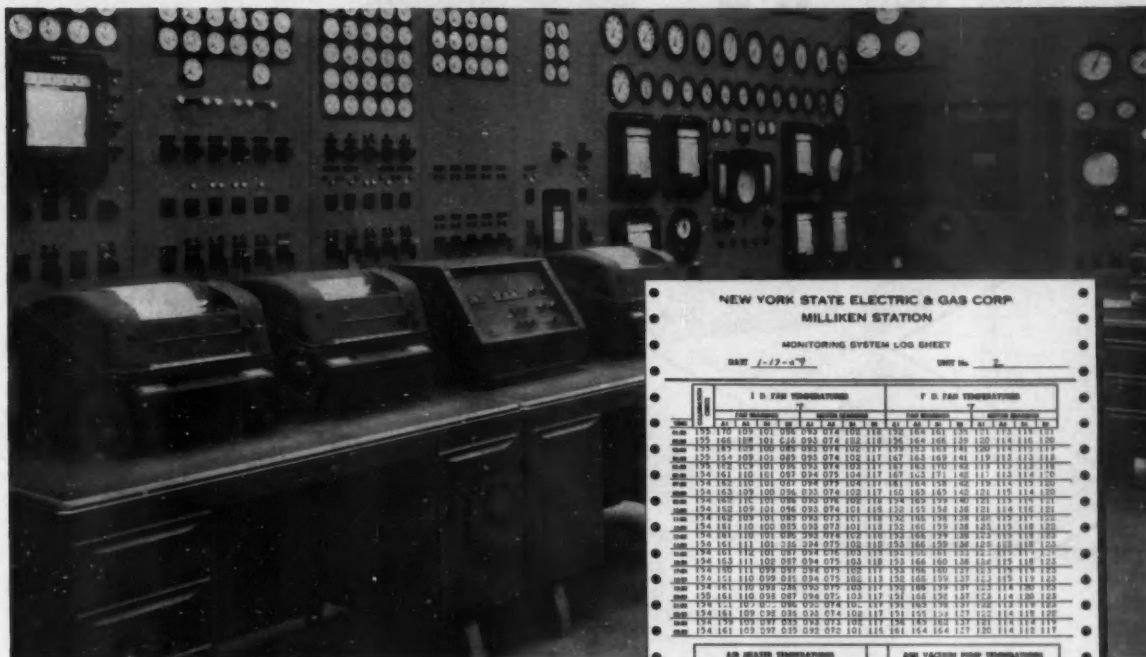
**2.**

Fill in your name, title,  
company and address.

**3.**

Mail card immediately.

## Automatic read-out . . .



Control room at Milliken power station, pictured here, shows three Teletype Model 28 Receive-Only Page Printers in foreground with control panel of Bailey Metrotype Information System. (Inset shows a sprocket-fed, continuous-type log sheet used in Teletype Page Printers.)

# Teletype equipment monitors and records power station performance

New Model 28 Teletype Page Printers and Tape Punch equipment provide a continuous, dependable data processing facility for evaluating power station performance. This Teletype communication equipment is part of a Bailey Meter Company Metrotype® Information System installed recently at the Milliken power station of the New York State Electric & Gas Corporation, near Ithaca, New York.

This installation consists of two data systems:

**1. A Monitoring System** that continuously scans a total of 282 variables—temperatures of fan, motor and pump bearings; pressures of water and oil pumps, etc. Whenever readings exceed prescribed limits, system immediately reads and prints complete digital data of off-normal operation. In addition, complete readings are printed hourly.

**2. A Performance System** that scans 66 points once every hour, measures generator output, main steam flow, feedwater flow, temperatures, etc. All factors required to evaluate the station's performance are logged on the Teletype Printers. A Teletype Tape Punch also produces a perforated tape for IDP.

Robert Darke, Systems Division Manager, Bailey Meter, says, "Teletype equipment was chosen for this installation because of its flexibility and proven reliability. Design is simple and trouble-free, and the units are manufactured specifically for round-the-clock rather than intermittent service."

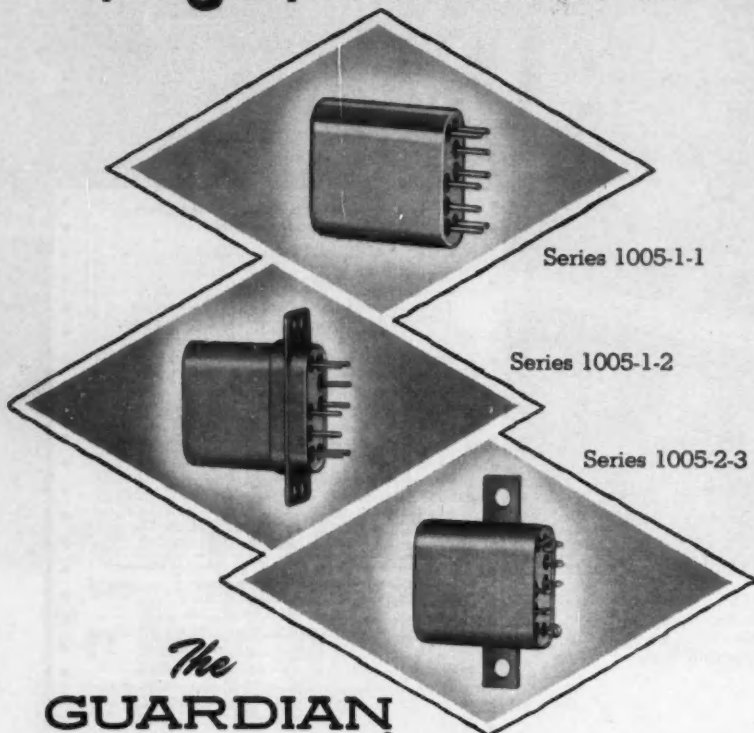
Teletype equipment will handle data for virtually any purpose in any industry. Signals may be serial or multi-wire. Signal medium may be local electrical circuit, telegraph or telephone circuit, or radio.

Why not find out how Teletype equipment can fit into your systems plan? Please write: Teletype Corporation, Dept. 22-H, 4100 Fullerton Ave., Chicago 39, Illinois.

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**CORPORATION**  
 SUBSIDIARY OF Western Electric Company Inc.

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**GUARDIAN**

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Series 1005-2-5



Series 1005-3-4

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- ◆ **Series 1005**—Available with 5 AMPERE contacts for 50,000 operations (min.) at 125° C., or 100,000 operations (min.) at 25° C., upon specification. Standard rating is 3 amperes at 125° C. non-inductive, 28 volts D.C. Applicable to MIL-R-25018 and MIL-R-5757-C specifications.
- ◆ **Fluxless Sealing**—A Guardian *first!* Eliminates cost of flux materials and the time required to apply it. Coil lead splices are the only internal connections using solder. Guardian's new exclusive fluxless solder sealing, in addition to use of non-gaseous materials, makes this relay adaptable to low energy level switching.
- ◆ **Tested and Proved**—Series 1005 operates on currents as low as 10 microamps at switching voltages of 30 millivolts with a minimum life expectancy of 1,000,000 operations.

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CIRCLE 150 ON READER-SERVICE CARD

CONTROL ENGINEERING

## WHAT'S NEW

(Continued from page 146)

missile guidance programs at AC. He was most recently director of gyro, components, and engineering services. Under his direction, the Thor guidance system was developed.

**Dr. F. Kenneth Brasted** has joined Texas Instruments, Inc. as administrative director of the central research laboratory. He was formerly president of the University of Dallas, a Catholic educational institution founded in 1955. **Richard C. Wood** has also joined TI to serve as marketing manager, advanced technologies, Central Staff Marketing Div. He was most recently with Lever Brothers as sales manager, industrial edible products dept. At TI, he will be responsible for marketing the research and development activities undertaken by the central research laboratory and he will also coordinate the company's relations with U. S. agencies.

**Frank C. Dyer** has been named vice president of planning for Alpha Corp., subsidiary of Collins Radio Corp. Previously he had been assistant manager of Collins' Texas Div.

**Bruce C. Harmon** has been appointed manager of the Akron branch office, Clark Controller Co. A graduate of Lehigh University, he had been in Clark's Cleveland office for 10 years.

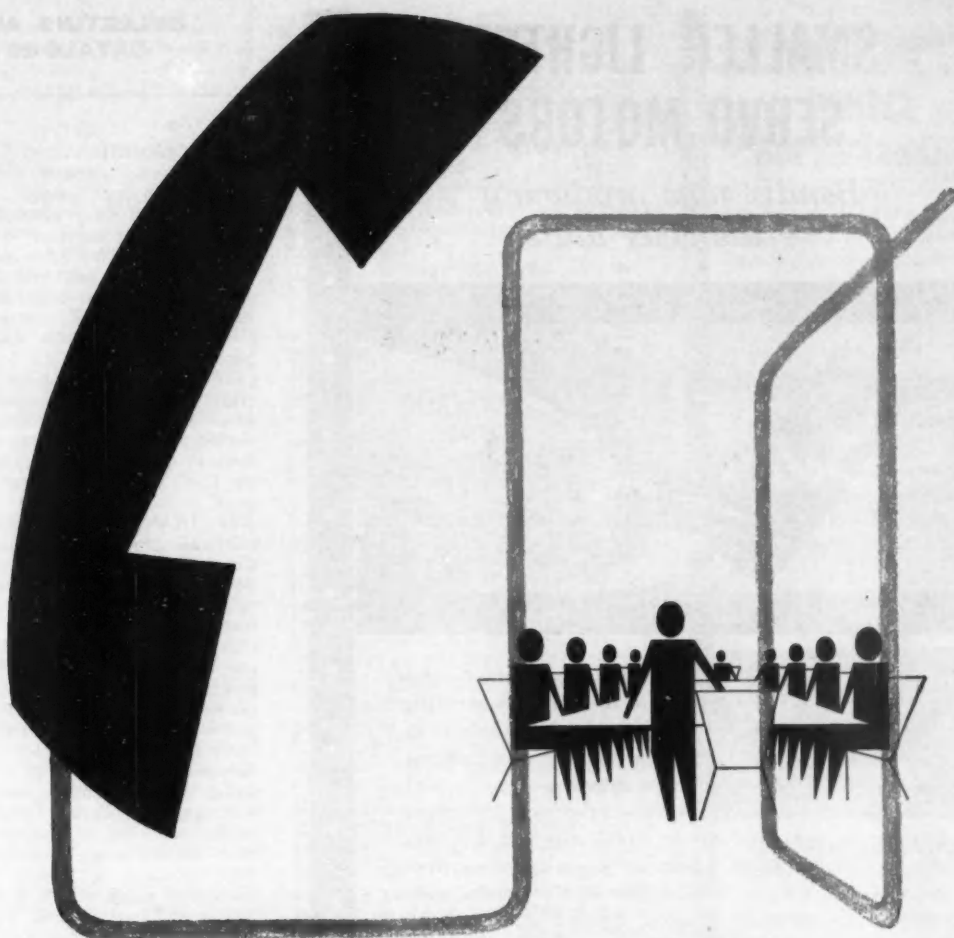
**William F. Boyd** has been elected vice-president for operations and general manager of Kellogg Switchboard and Supply Co. Div. of International Telephone and Telegraph. He succeeds George T. Scharffenberger who resigned.

**Lilburn A. Lawson** has been appointed chief engineer, Osborne Electronic Corp. He had been assistant chief engineer at the Portland manufacturer of transformers.

**Lisle R. Sheeley** has been appointed manager of sales, General Electric Computer Dept. in Phoenix. He had been manager of sales for mobile radio equipment at GE's electrical communication products dept.

**Hal V. Miller** has been named liaison engineer at Redbank, N. J. for the Technical Products Div., Packard Bell Electronics Corp. Previously he had been an engineer with the Western Electric Co. in Winston Salem, N. C.

**L. L. Porter** has been elected treasurer of Knapic Electro-Physics, Inc., Palo Alto supplier of silicon and germanium monocrystals. **Robert D. Yeaman** has been elected secretary of the Palo Alto firm.



## How to turn your telephone into a conference room

*Another of the many ways ITT electronics saves time and money and speeds output*

Flick the dial of an ITT intercommunication telephone.

Instantly, it becomes a "conference room"—linking 10 key people simultaneously.

They talk together, exchange ideas, reach decisions—*without leaving their desks!*

### **ITT electronics—a help for business**

This ten-party conference telephone is one of hundreds of ideas developed by ITT's Kellogg Switchboard and Supply Company and other ITT units to help perform tasks—faster.

ITT supplies telephone systems for entire countries. It develops communications and guidance for missiles; radio aids for aircraft and ships; microwave systems that control the flow of oil, gas, and electric power.

Nations are joined by ITT coaxial cable systems; news of the world is broadcast by ITT transmitters and power tubes—in fact, ITT equipment is produced for every communications need of business, industry, and government.

### **Skills for international projects**

ITT has decades of experience in operating nationwide telephone networks. ITT System commercial circuits—cables, radiotelephone, radiotelegraph, and marine radio—cover the earth.

An ITT System company operates and maintains the 3,000-mile DEW Line in the Arctic, the White Alice communication network in Alaska, and other vital lifelines of defense. ITT has the senior part in planning the modernization and extension of the Air

Force's global communications concept called AIRCOM.

In countless other ways ITT System research, production, and service are speeding the world's growing communications traffic.

For information on any communications system write to ITT, 67 Broad Street, New York 4, N.Y.



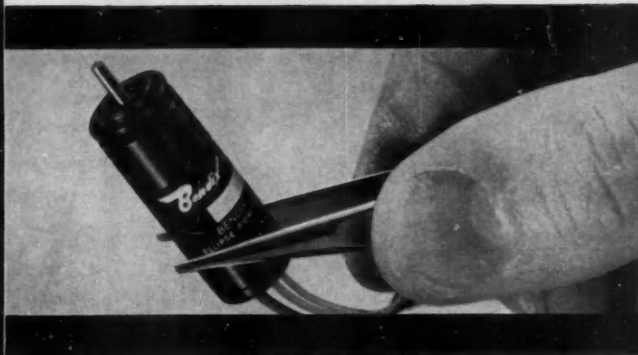
*... the largest American-owned world-wide electronic and telecommunication enterprise, with 101 research and manufacturing units, 14 operating companies and 130,000 employees.*

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CIRCLE 152 ON READER-SERVICE CARD

CONTROL ENGINEERING

## BULLETINS AND CATALOGS

(300) SOLENOID VALVES. Automatic Switch Co. Condensed Valve Catalog No. 202, 36 pp. Complete descriptions of 2-, 3-, and 4-way solenoid valves are preceded by six pages of valuable engineering data. Three flow nomographs, with instructions and typical examples, simplify the proper selection of valve sizes for steam, liquids, and gases.

(301) TEMPERATURE CONTROLS. Burling Instrument Co., Inc. Catalog G-22, 4 pp. Reviews the size, range, and other features of a complete line of differential expansion instruments for the electric or pneumatic control of temperatures to 2,000 deg F. Photos illustrate standard, weathertight, and explosion-proof enclosures.

(302) TRANSISTOR CHART. Semiconductor Products, Bendix Aviation Corp. Chart, 2 pp. Lists primary applications, maximum ratings, and typical operating characteristics of all Bendix production transistors.

(303) TINY GYRO COMPASS. American Bosch Arma Corp. Booklet. Brand new comprehensive publication describes the world's smallest complete gyro compass for marine and land navigational use.

(304) HYDRAULIC SERVOS. Eastern Industries, Inc. Brochure, 6 pp. Describes this company's activities in the field of electrohydraulics. Two typical examples are cited: a magnetron tuning servo and a missile elevon control servo. Brief component descriptions follow.

(305) PIPELINE CONTROL. Union Switch & Signal Div. of Westinghouse Air Brake Co. Bulletin, 4 pp. Presents Union's philosophy on the system approach to precision pipeline control. Photos show some of the pre-designed packaged units that handle pipeline data in coded digital form.

(306) PRESSURE TESTING. U. S. Science Corp. Bulletin, 8 pp. Reviews the operation and application of two new dynamic pressure test sets: the 700 Series, a dual-pressure unit for testing mach number controls, pressure ratio controls, balancing systems, etc. and the 800 Series, single-pressure unit for the production and field testing of transducers and various altitude controls.

(307) ADJUSTABLE-SPEED DRIVES. The Louis Allis Co. Bulletin 3600, 6 pp. Covers the design features and various modifications of the Allispede line of mechanical adjustable-speed drives. Tables list principal dimensions, speed variations, and frame assignments for various power ratings.

(308) MERCURY RELAYS. The Adams & Westlake Co. Bulletin, 4 pp. Illustrates four popular models from a complete line of mercury-to-mercury relays. Three sketches of a typical operation show how these units provide a fixed time delay and snap action without pitting.

(309) ASPHALT BLENDING. B-I-F Industries, Inc. Bulletin SM-9477, 8 pp. Part of a series on standard methods, this paper describes the operation and advan-

tages of a system for in-line blending of asphalt cutbacks direct to trucks and tank cars. Typical operating schematics show the process and control equipment involved.

(310) **LABORATORY MEASUREMENTS.** Weston Instruments, Div of Daystrom, Inc. Brochure, 8 pp. Authored by John H. Miller, former vice-president and chief engineer at Weston and now a consultant, this publication describes the selection and application of laboratory measuring instruments. Sections cover the various types of instruments used, the effects of overloads, proper handling techniques, and the more common instrument accessories.

(311) **FIFTEEN SWITCHES.** Control Products, Inc. Bulletin, 4 pp. Photos, dimension drawings, and complete specifications are provided for eight high-temperature thermal switches and seven button, toggle, and lever operated waterproof switches.

(312) **OPTICAL GALVANOMETERS.** The Ealing Corp. Folder, 6 pp. Describes the Pye Scalamp line of precision galvanometers and other special-purpose instruments. A log-log plot shows voltage sensitivity as a function of source resistance, and a table lists prices and specifications for eight different models.

(313) **MYLAR MAGNETIC TAPES.** E. I. DuPont de Nemours & Co. Bulletin A-11076, 10 pp. Summarizes the results of study conducted to determine the base material's contribution to the reliability of magnetic recording tapes. Graphs and tables compare the performance of Mylar tapes with that of various acetate films and point up the superiority of the former.

(314) **SPEED REDUCERS.** Metron Instrument Co. Bulletin No. 97, 4 pp. Both standard and anti-backlash types of miniature speed reducers, with over 400 available speed ratios, are described here. Photos illustrate typical applications, and cutaway views reveal the internal construction of both types.

(315) **SPECTROPHOTOMETER.** Beckman/Scientific and Process Instruments Div. Bulletin 724, 20 pp. Shows how the Beckman IR-5 Double-Beam Infrared Spectrophotometer serves to provide thousands of qualitative and quantitative analysis in the industrial laboratory. Also includes instrument specifications, performance data, and information on accessories.

(316) **RING BALANCE METER.** Hagan Chemicals & Controls, Inc. Bulletin MSP-160, 8 pp. Highlights the important features of Hagan's versatile Ring Balance Meters. Each page describes a different feature and the advantages this affords in various applications.

(317) **AIR & VACUUM PUMPS.** Leiman Bros., Inc. Catalog No. 359, 16 pp. Includes construction details, dimensions, capacities, performance curves, and installation data on a complete line of rotary positive-displacement air and vacuum pumps, gas boosters, air motors, and a full line of accessories.

(318) **MAGNETIC MULTIPLEXER.** Cubic Corp. Bulletin No. 200-M, 4 pp. Reviews the advantages and operating potential of a brand new magnetic multi-

plexer that is now in the advanced stages of development and available for pre-defined applications. A typical system block diagram illustrates its major components.

(319) **PHOTOELECTRIC CONTROLS.** General Electric Co. Bulletin GEA-6822, 16 pp. Covers GE's full line of photoelectric relays and controls, and contains a 2-page selection guide. Line drawings at the bottom of each page show typical applications of the different types of equipment.

(320) **FLOW TRANSMITTERS.** Fischer & Porter Co. Specification Sheet 10B-1460, 4 pp. Deals with two new differential pressure transmitters for accurate in-line metering of low gas or liquid flows. Also contains a useful nomograph for proper sizing and equations for determining equivalent water or air values for maximum process fluid flow rates.

(321) **COMPONENT RECTIFIERS.** General Electric Co. Brochure ECG-344, 24 pp. Entitled "Designing With G-E Vac-U-SEL Component Rectifiers", this publication consists of three sections: a basic information section which reviews fundamental characteristics; a product description section dealing with finishes, construction, and nomenclature; and a selection section on typical applications.

(322) **LABORATORY CHROMATOGRAPH.** Consolidated Electrodynamics Corp. Bulletin 1831B, 16 pp. Describes the features of CEC's Type 26-201A Laboratory Chromatograph, and emphasizes some difficult applications such as the rapid analysis of natural gasoline and other hydrocarbons.

(323) **INSTRUMENT PANELS.** Bailey Meter Co. Product Specification G71-7, 16 pp. Provides construction details, dimensions, weights, and instrument mounting data on six standard styles of instrument and control panels. Standard procedures for tubing and wiring are presented along with a checklist on ordering information.

(324) **ACCELERATION SWITCHES.** Inertia Switch, Inc. Bulletin, 4 pp. Emphasizes the reliability, accuracy, and simplicity of the company's new line of acceleration-sensitive switches. Lists three available types: axial units for accelerations along a given line, radial units for acceleration in any given plane, and omnidirectional units that will respond to acceleration in any direction.

(325) **AUTOMATIC ORDER PICKING.** Atronic Products, Inc. API Report No. 105-98-2, 7 pp. Describes an automatic order picking system built around an Atronic Products' Model 420 Automatic Carton Selector and an order insertion control console. This system will deliver cartons to a number of trucks simultaneously in a prescribed sequence for partial load deliveries from each truck on a multi-stop route.

(326) **REACTOR MONITORING.** The Thompson-Ramo-Wooldridge Products Co. Brochure, 8 pp. Discusses a number of applications of the RW-300 digital control computer in the nuclear field. Special attention is given to a system for detecting ruptured fuel elements; this system uses two RW-300 computers to continuously monitor the radioactivity of cooling gases.

*P.S. and don't forget these other quality products at the*

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Teterboro, N. J.



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**AUGUST 1959**

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- In a Class by Itself, But Compares in Functions to Computers Costing Over \$1,000.00
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The lowest priced computer of its quality available anywhere, the new Heathkit EC-1 Computer now puts advanced engineering techniques within reach of all.

Industry will find the EC-1 invaluable in trial solutions to mechanical and mathematical problems . . . shortens engineering time, speeds up preliminary work, frees the advanced-computer time for more complex problems and final solutions. And the EC-1 aids in training computer operators and acquainting engineers with computer versatility and operation.

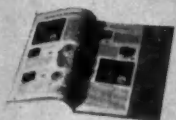
Schools and colleges will find the EC-1 ideal for teaching and demonstrating in engineering, physics, and math classes; perfect for laboratory use in teaching computer design and applications.

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**SPECIFICATIONS:** Amplifiers: 9 D.C. Operational Amplifiers using one 608 per amplifier; each solves mathematical problems; each balanced by individual panel control without removing problem set-up. Computing components mount on connectors and plug into panel sockets. Open loop gain approximately 1000. Output -60 to +60 volts at 5 ma. Power Supplies: +300 volts at 25 ma electronically regulated; variable from +250 to +350 by control with meter reference for setting +300 volts. Negative 150 volts at 40 ma regulated by VR tube. **Coefficient Potentiometers:** Five on panel. **Initial Condition Potentiometers:** Three on panel; used to introduce initial velocity, acceleration, etc. on the three "given" quantities. **Repetitive Operation:** Multivibrator cycles a relay at adjustable rates (1 to 15 CPS), to repeat the solution any number of times; permits observation of effect on solution of changing parameters. **Meter:** 50-0-50 us movement. **Power Requirements:** 105-125 volts, 50-60 cycles, 100 watts. **Dimensions:** 19 1/2" W. x 11 1/2" H. x 15" D.

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CIRCLE 154 ON READER-SERVICE CARD

## ABSTRACTS

### Capacity Probe System

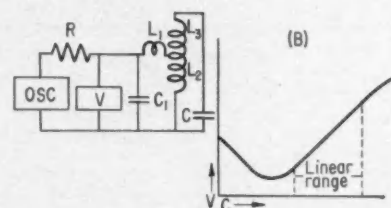
From "Versatile Capacity Measuring System for Level Control and Stream Analysis" by E. N. Shawhan, H. L. Bachofer, J. Lerner, and J. R. Wright, Sun Oil Co. Paper presented at Session on Instruments during the 24th Midyear Meeting of the American Petroleum Institute's Division of Refining in the Statler Hilton Hotel, New York City, May 27, 1959.

The dielectric constant of a material is a physical property related to the electric polarization of its molecules and is characteristic for each substance. This property has found numerous applications in a variety of measurements but its potential as a tool in petroleum refining has perhaps not been fully realized.

The system has evolved as the result of field experience, with particular attention to installation and maintenance considerations. The electronic portion of the system is standard with flexible adjustments for a variety of problems. The capacity sensing probes are similar for each type of application. A small rugged transmitter is mounted near the point of measurement. The electronic chassis with the span and zero controls is mounted in the control house for ease of maintenance and adjustment. They can be separated a mile or more.

The basic electrical circuit is shown in Figure 1A.  $V$  is the voltage across

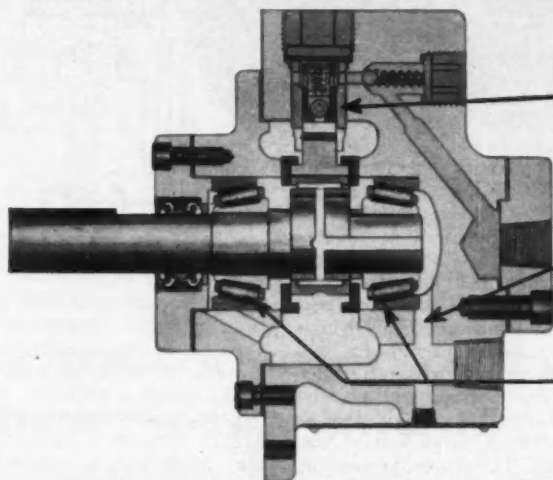
FIG. 1. (A)



a transmission line changed by the remote capacity  $C$ . The relation between  $V$  and  $C$  is of the form in Figure 1B.  $C_1$  includes the cable capacity.  $L_2$  and  $L_3$  form a tight-coupled autotransformer. The minimum point of the curve occurs when reflected capacity across  $L_2$  caused by  $C$  forms a series resonant circuit with  $L_1$ . As  $C$  increases, the impedance across  $L_2$  decreases.  $C_1$  is chosen so that  $C_1$  and  $L_1$  form a parallel resonant circuit when  $C$  is very large. Between the conditions for series and parallel

AT PRESSURES TO 5,000 PSI . . .

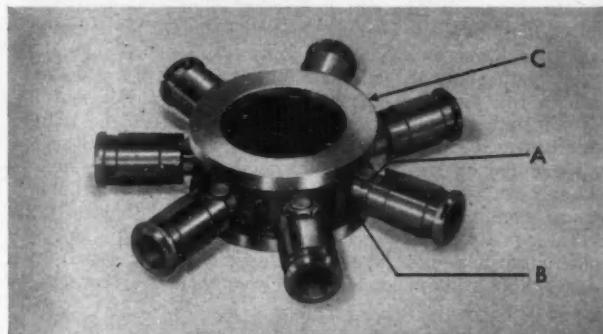
# Only the AE Hydramite offers all these advantages



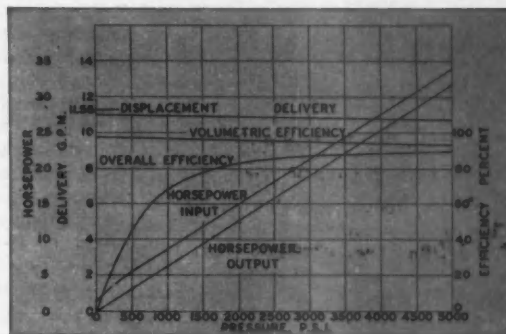
Liners and plungers are honed and individually mated for optimum fit.

Low friction losses. Pump operates with case flooded. Oil is ported to take advantage of natural pumping action of tapered bearings.

Heavy duty, high capacity tapered roller bearings absorb more punishment . . . handle maximum unbalanced loads . . . last longer.

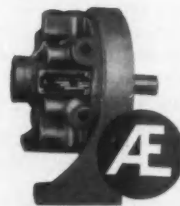


**Positive pumping action.** The Hydramite has no cam follower springs to fail. Plungers (A) are connected to curved slippers (B) which are held against the outer race of cam shaft needle bearing by two plunger return rings (C). As the shaft revolves, each plunger is pushed outward in succession and then pulled inward by the return rings.



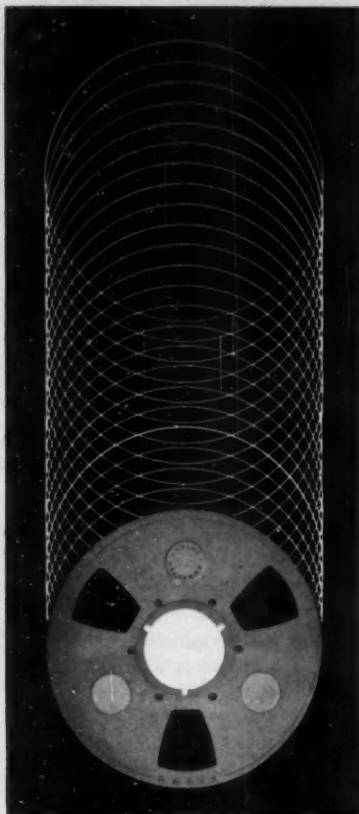
**High efficiency.** With a Hydramite you get an overall efficiency of 85%. Its flat overall high efficiency curve has little variation between 1,500 and 5,000 psi. What's more with a Hydramite you get positive suction. There is no requirement for super-charging equipment which deducts from system efficiency.

**To meet your specific requirements,** Hydramite pumps can be supplied for constant displacement from 3 to 30 gpm at 5,000 psi and 70 to 85 gpm at 3,000 psi for hydraulic fluids with viscosities of 150 to 300 ssu at 100° F. In special applications they have handled viscosities as low as 40 and as high as 900 ssu at 100° F. Special materials and seals permit handling of missile fuels and special fluids at higher temperatures. Available in flange, foot or face mounted styles. Write or call American Engineering Company, Philadelphia 37, Pennsylvania. Phone: Cumberland 9-3800.



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*Maximum Security with  
Minimum Clearances*

Ever have trouble with the edge-track data on your magnetic tape? Possibly an Ampex Precision Reel could have prevented the difficulty. How? The secret is in the metal. Only Ampex makes precision reels of magnesium. It gives you thick, rigid, nontapered flanges that protect the tape. A strong hub, too, that doesn't distort under pack pressure. And because magnesium is light, Ampex achieves this extra strength within the weight limits your recorder is accustomed to. All this, together with a calculated design that means minimum clearances and tolerances, gives you a better tape pack—pass after pass. The security of Ampex Precision Reels is available in all conventional recording sizes.

**AMPEX  
MAGNETIC TAPE**

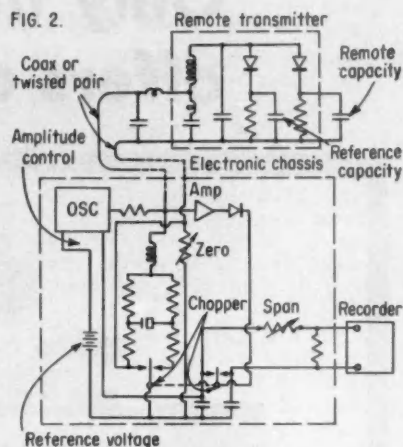
934 CHARTER STREET, REDWOOD CITY, CALIF.

## ABSTRACTS

resonance is a considerable linear range that is used for measurement of  $C$ . In a practical design the 1-percent linear range may be 400 mmf to 500 mmf. This range can be extended to several thousand micromicrofarads by shunting  $C$  with resistance. Changes in cable capacity alter  $C$ , and slightly change the slope of the curve. The system compensates for this effect, and operation is independent of variations in cable characteristics.

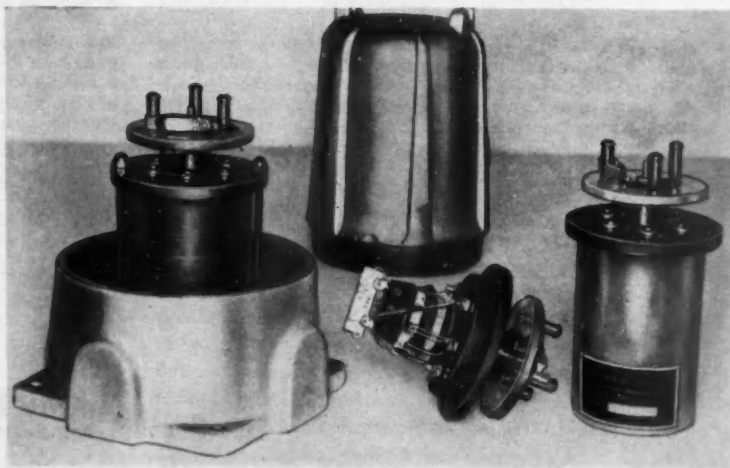
Figure 2 shows a block diagram of the system. The measurement precision results from the method of alternately substituting a reference capacitor and the unknown capacity for  $C$  in Figure 1. The difference in capacities of the unknown and reference capacitors can be measured much more accurately than the capacity of either alone. With a stable reference it is practical to measure small changes in a large remote capacity.

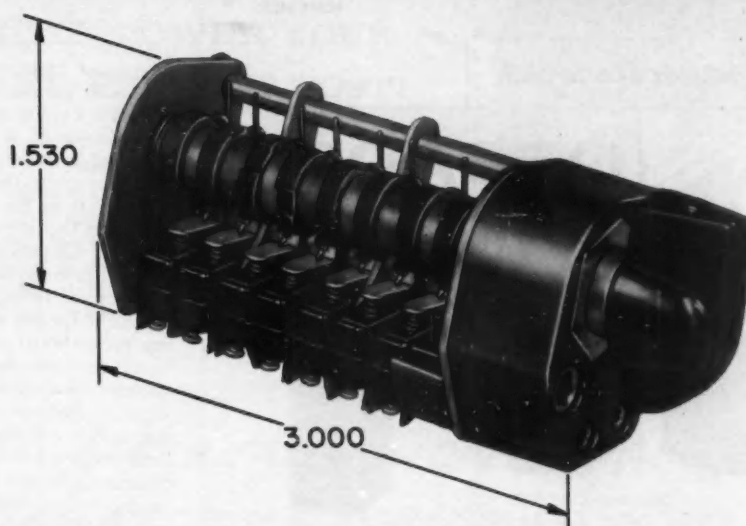
A self-driven polarized relay alternately applies positive and negative voltage to the transmission line in addition to the excitation voltage from the oscillator. This low-frequency voltage alternately switches the reference and unknown capacities into the circuit of the remote transmitter by making one or the other of the diode switches conducting. The amplifier rejects the switching voltage and passes only an alternating-current voltage proportional to the capacity connected to the transmitter. This voltage alternates between two amplitude levels unless the unknown and reference capacities are equal. The rectified amplifier output is connected to either of two integrating capacitors by the relay in synchronism with the alternation of the switching voltage.



One integrating capacitor is charged to a potential proportional to the remote reference condenser and the other to the unknown capacity.

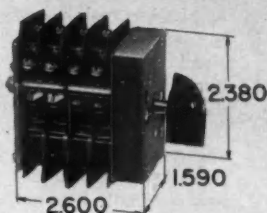
The system is stabilized by controlling the oscillator amplitude. The difference between a fixed voltage and the direct-current potential corresponding to the remote reference capacity is applied to the oscillator as an error voltage. If the value of the remote reference capacitor is chosen on the linear portion of the curve in Figure 1B, the oscillator amplitude is adjusted to compensate not only for changes in gain around the control loop, but also holds fixed the point on the curve corresponding to the reference capacity. Because the minimum point of the curve is independent of cable capacity, regulation of the oscillator amplitude holds the slope of the voltage-capacity curve constant for considerable changes in cable capacity.



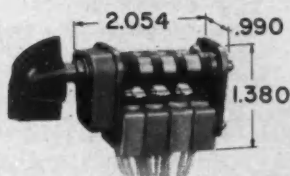


## New rotary selector switch assemblies feature "cock-and-fire" actuation

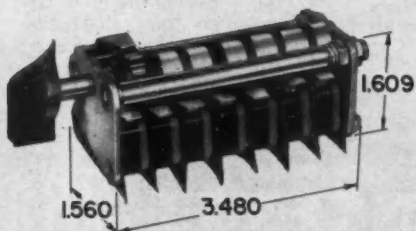
### OTHER ROTARY ASSEMBLIES



"20AS" series double-row "V3" assembly  
(Knob not furnished)



"25AS" series sealed subminiature  
assembly (Knob not furnished)



"7AS" series single-row "V3" assembly  
(Knob not furnished)

The new "28AS" Series of rotary selector switch assemblies have a "cock-and-fire" actuating mechanism that moves positively from one position to another, imparts a good feel of the detent action and provides immediate indication of each position. Aircraft engineers have found these switches ideal for mounting in close-coupled designs. Features include:

#### Reliable Operation

Individual actuating levers pivot on a common rod, insuring maintained adjustment. The levers are operated by precision cams which are rigidly mounted on the actuator shaft. A seal ring on the shaft keeps out moisture. Panel seals are optional.

#### "Non-Tease" Circuitry

The actuating mechanism moves positively from one position to another. There is no possibility of circuit "tease" or actuator "hang-up" between the 90° detents.

#### Variety of Sequences

Up to seven basic switches and two or three actuator positions may be provided. Innumerable sequences can be factory-adjusted to fit specific circuit requirements.

*Send for Data Sheet 162*

For information of the "28AS" Series or other versatile MICRO SWITCH rotary switches, consult experienced engineers at your nearby branch—or write to:

MICRO SWITCH . . . FREEPORT, ILLINOIS

A division of Honeywell

In Canada: Honeywell Controls Limited, Toronto 17, Ontario



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MICRO SWITCH Precision Switches

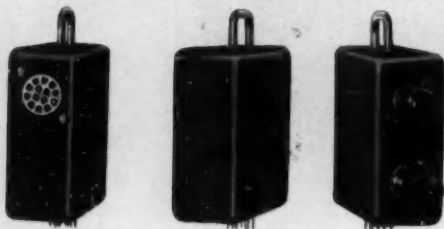
**NEW  
EECO**

See them at the  
**WESCON SHOW**  
BOOTH 2413

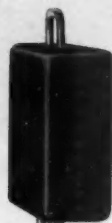
*Transistorized*

**DECADES**

for extremely  
reliable operation  
in the 0 to 250 kcs range



ONE-THIRD ACTUAL SIZE



#### APPLICATIONS

New EECO N-Series Transistorized Decades are miniaturized plug-in units designed for reliable pulse counting and frequency division in the frequency range of 0 to 250,000 pulses per second.

#### FEATURES

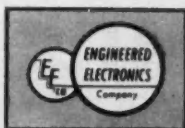
- Small, compact size.
- Simple power supply requirements (for example, Models N-101 and N-102 require only -12 volts).
- Low power consumption.
- Compatible with EECO T-Series circuits.
- Auxiliary 9-step staircase output available.
- Most units plug into special 13-pin miniature socket. Others take standard 29-pin socket (Continental No. MM-29-22S).
- Pin connections arranged for in-line wiring of power and grounds.
- Extreme reliability, due to saturation techniques and consistent derating of component tolerances.

#### WIDE SELECTION

EECO N-Series plug-in Decades are available in the following standard models:

MODEL	DESCRIPTION
N-101	No readout.
N-102	Incandescent readout.
N-104	Incandescent readout (remote). Typically a projection readout module.
N-105	Nixie readout. (Can be cabled to remote Nixie.)
N-106	Nixie readout with preset control switch. (Can be cabled to remote Nixie.)
N-107	Incandescent readout with inputs for external preset control.
N-108	Incandescent readout (remote) with inputs for external preset control.
N-111	No readout, but with 1-2-4-2 code.

*Additional information on N-Series Transistorized Decades and other EECO products available on request.*



**ENGINEERED ELECTRONICS COMPANY**  
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CIRCLE 158 ON READER-SERVICE CARD

CONTROL ENGINEERING

#### ABSTRACTS

In practice, the remote reference capacitor is chosen greater than the minimum capacity to be measured. The zero of the system can then be adjusted by the zero control on the chassis. It is a variable resistance switched in series with the cable impedance when the remote unknown capacity is in the circuit and shorted out when the reference capacity is connected. Changing the zero adjustment has only slight effect on the slope of the voltage-capacity curve.

The output is a direct-current voltage proportional to the difference between the unknown and reference capacities. The ratio of output voltage to capacity difference depends only on the remote reference capacity and the local reference voltage. The span adjustment changes this fraction of the output voltage applied to the recorder or controller. The span can be changed over a wide range without affecting the zero, i.e., span and zero adjustments are independent.

Figure 3 (page 156) is a photo of the transmitter in three stages of assembly. An "O" ring around the bakelite top seals against corrosive vapors. The three studs on the lucite disk are used to check overall operation. The probe is connected to one and high and low check capacitors to the other two. A clip lead switches the transmitter to either of the check capacitors.

The paper describes applications and probe designs for level measurement, stream analysis, and moisture measurement. In capacity level measurement, the probe design is suitable in applications with temperatures ranging from minus 300 to plus 600 deg F, provided the probe is made of suitable materials. Also discussed are ways of compensating level measurements for changes in temperature or dielectric constant or both of the material being measured.

#### Electric-Furnace Computer

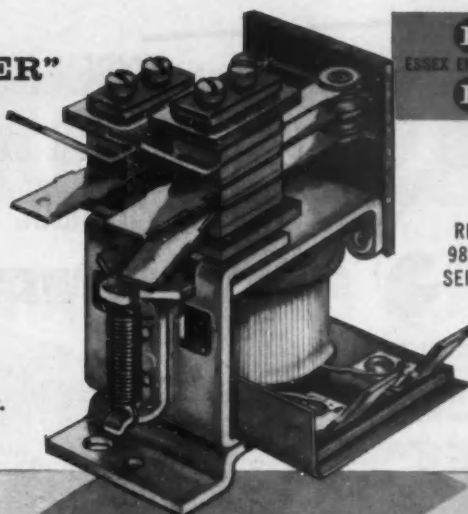
From "Concerning the Use of a Computer for Regulating the Amount of Electric Energy Supplied to an Electric-Arc Furnace" by Yu. M. Alyshev, L. N. Fitsner, and L. I. Shechenko (Moscow). "Avtomatika i Telemekhanika", Vol. 20, No. 2, February, 1959, pp. 206-210 (USSR).

The automatic control of an electric furnace based on a constant power input can minimize the voltage fluctuation of the power supply. This can be realized by introducing a com-

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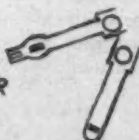
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FILE NOS. E12/39 OR E22381



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ELIMINATES DRIFT;  
ASSURES CONTACT  
STABILITY



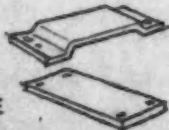
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CONTACTS AVAILABLE  
FOR LOW VOLTAGE AND/OR  
LOW CURRENT CIRCUITS



SIMPLIFIED MAGNET  
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ACTION

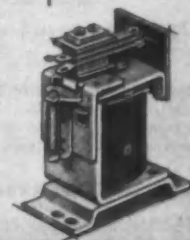


VARIETY OF  
MOUNTINGS AVAILABLE



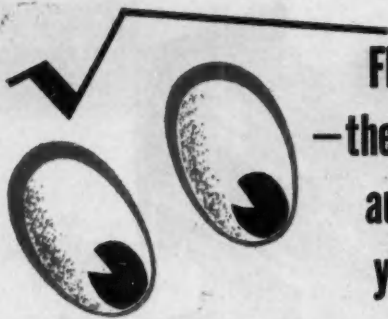
OTHER FEATURES	AC. 98000 TYPE	DC. 98600 TYPE
• MAX. COIL VOLTAGE	230 AC	115 DC
• MAX. COIL RES. IN OHMS	—	20000
• MAX. COIL WATTS OR VOLT AMPS.	9.0 VA. IN RUSH 6.5 VA. SEALED	4.0 W.
• MAX. CONTACT FORM WITH RATED CURRENT AT 32 V. DC OR 115 V. AC (NON-INDUCTIVE LOAD)	2PDT 15 AMPS. 4PDT 6 AMPS. 6PDT 3 AMPS.	2PDT 15 AMPS. 4PDT 6 AMPS. 6PDT 3 AMPS.
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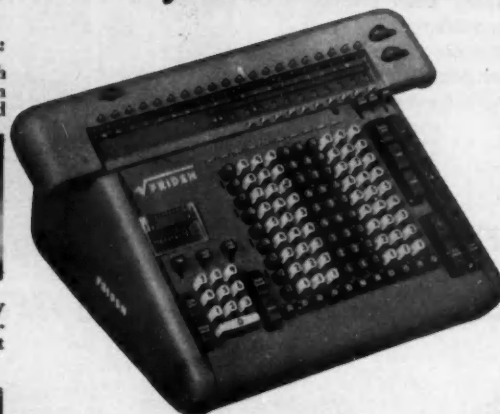
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**3** See root appear in dials. This figure can be retained on keyboard if desired for further calculation. Need for copying root is eliminated



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CIRCLE 160 ON READER-SERVICE CARD

160

CONTROL ENGINEERING

## ABSTRACTS

puting device into the conventional control system which maintains a fixed voltage-to-current ratio  $k$  for each of the three phases. The computing device has three identical parts, each consisting of a multiplying unit, an integrating unit, and a stabilizer.

The instantaneous values of the current and voltage of a phase are multiplied in one of the multipliers. The voltage output of the multiplier (proportional to the electric arc power) is compared with a predetermined magnitude, and the difference is integrated. In the stabilizer (a choke coil) the output of the integrator is used to correct the predetermined value of  $k$  so that the value of  $k$  will be adjusted to maintain a constant power input whenever there is a voltage fluctuation of power supply.

A circuit diagram is given of the proposed computer. The experiment conducted on a 20-ton electric furnace shows that the use of a computer in the control system reduces the amplitude of maximum power fluctuation from plus or minus 11 to plus or minus 1 percent. There are three figures, and five Soviet references.

## Ways to Sense Rotary Speed

From "Proposed Recommended Guide for Measurement of Rotary Speed" by Rotary Speed Measurements Subcommittee of the Special Instruments and Auxiliary Committee, American Institute of Electrical Engineers, NYC, April 1959. (Published for comment and criticism.)

"The primary purpose of this Guide is to describe the instruments and methods commonly used for the measurement of rotary speed or slip and to give information regarding the characteristics and limitations of commercially-available instruments ordinarily employed in connection with testing of electric machinery."

The Guide proposes definitions of such terms as revolution counter, rotary speed, slip, speed indicator, stroboscope, tachometer, and tachoscope. Considerable emphasis is placed on classification of methods and equipment, among which are tachometers and counter and time piece, frequency measurement, and stroboscopic methods.

Also described are methods of measuring slip, general considerations in applying and driving speed measuring devices, and precautions in the care and use of these instruments.

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$I_c \text{ max.}$	5	5	5	5	7 amp.
$I_{sa} (V_{ce} \text{ 2 volts})$ Typical 25°C.	65	65	65	65	65 μ s.
HFE (3 amp.)	—	60-150	30-75	30-75	—
HFE (5 amp.)	—	—	—	—	20-50
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$V_{ceo} (I_c = 1 \text{ amp.})$	40 typical	50 typical	60 min.	60 min.	60 volts min.
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CONTROL ENGINEERING

## NEW BOOKS

### Magamps Simplified

THE THEORY AND DESIGN OF MAGNETIC AMPLIFIERS. Dr. E. H. Frost-Smith. 487 pp. Published by John Wiley & Sons Inc., New York, 1959. \$12.50.

Dr. Frost-Smith's contributions to the technology of magamps date back to 1949, when he began publishing his many valuable papers on the low-level forms of these devices. His long connection with Elliott Brothers, Ltd. has given him a unique opportunity to investigate and apply magamps to various military and industrial applications. This reviewer had the pleasure of meeting the author when he visited New York in 1953 with other British scientist on a special mission to study U.S. progress in the field of magnetics.

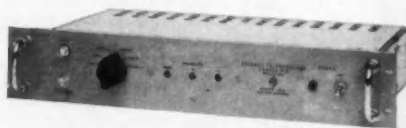
The new book by Dr. Frost-Smith is a textbook aimed at the practicing control engineer as well as the university student. He clearly explains the theory of operation of magamps, their design methods, and their applications. Several new and important problems are presented and their solutions completely described. When a particular magamp is a part of a closed-loop system, its equivalent block diagram is derived, and its transient behavior is analyzed and explained. The time constants of capacitive and inductive loads and their dependence on "conduction angle" are derived for the first time. The design of several typical circuits is given in detail, and frequency-response characteristics and Bode plots are provided.

The book is easy to read; all formulas are derived through the use of Kirchhoff equations and elementary calculus. The reader will not find the cumbersome mathematics that becloud many papers and books on magnetic amplifiers. In the first six chapters, the author analyzes saturable reactor circuits, with and without feedback and for resistive and reactive loads. Chapters 7 and 8 deal with closed-loop systems, with emphasis on frequency response, factors causing time delays, and transients due to various kinds of loads. Ramey circuits and other high-speed magamps are treated in Chapter 9. The extension of the Ramey concept to three-phase magamps (developed in England by A. E. Maine) is also presented.

Chapter 10 contains 38 pages on various push-pull circuits for dc and ac loads of both resistive and reactive forms. In Chapters 11 and 12, the author examines the important group

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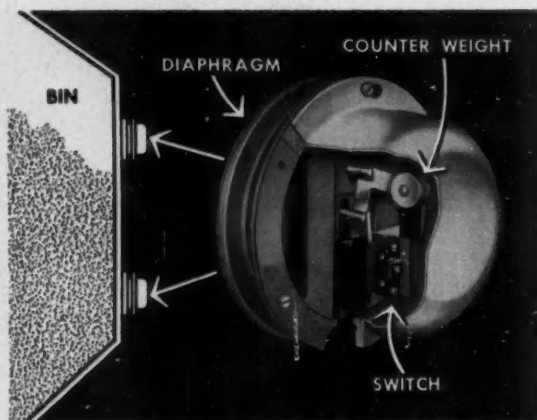
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**CIRCLE 164 ON READER-SERVICE CARD**

**CONTROL ENGINEERING**



**SERIES 400**

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## NEW BOOKS

of low-level magnetic amplifiers and modulators. Considerable attention is given to causes of zero drift and gain drift and the means of reducing both. The last two chapters are concerned with the design and construction of magamps for specific applications.

—Michel Mamon  
IT&T Laboratories

### R&D Appraisal

**YARDSTICKS FOR INDUSTRIAL RESEARCH**, James Brian Quinn, Dartmouth College. 224 pp. Published by the Ronald Press Co., New York. \$6.50.

This book describes ways and means for the evaluation by management of industrial research output. Based principally upon an intensive survey of the practices of large companies, it attempts to develop practical schemes for judging the economic and technical performance of specific completed research programs in order to guide future action. The book is intended to help administrators of research conducted by private business, the foundations, and the government.



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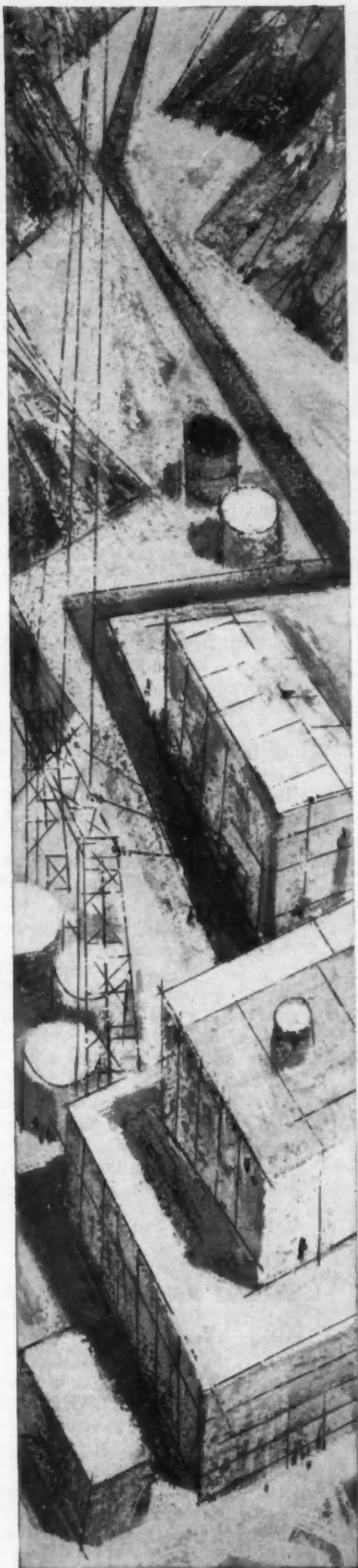
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### Research Laboratories Division

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## MEETINGS

### AUGUST

Western Electronic Show and Convention (WESCON), sponsored by IRE and AIEE, Cow Palace, San Francisco, Calif. Aug. 18-21  
Annual Army Navy Instrumentation Program (ANIP), Symposium and Industry Briefing, Statler Hilton Hotel, Dallas, Tex. Aug. 21-Sept. 2  
Gordon Research Conference on Instrumentation, Colby Junior College, New London, N. H. Aug. 24-28

### SEPTEMBER

Association for Computing Machinery, 14th National Conference, Massachusetts Institute of Technology, Cambridge, Mass. Sept. 1-3.  
American Automatic Control Council, General Assembly of IFAC, Edgewater Beach Hotel, Chicago, Ill. Sept. 14-18  
Instrument Society of America, 14th Annual Instrument Automation Conference and Exhibit, International Amphitheater, Chicago, Ill. Sept. 21-25  
Third Industrial Nuclear Technology Conference, sponsored by Armour Research Foundation and Nuclear Magazine, Morrison Hotel, Chicago, Ill. Sept. 22-24  
Fourth Annual Special Technical Conference on Non-Linear Magnetics and Magnetic Amplifiers, sponsored by IRE and AIEE, Shoreham Hotel, Washington, D. C. Sept. 23-25  
American Institute of Chemical Engineers, National Meeting, Hotel St. Paul, St. Paul, Minn. Sept. 27-30  
Institute of Radio Engineers, 1959 National Symposium on Telemetering, Civic Auditorium, San Francisco, Calif. Sept. 28-30  
American Society of Mechanical Engineers, National Power Conference, Muehlebach Hotel, Kansas City, Mo. Sept. 28-Oct. 2

### OCTOBER

Institute of Radio Engineers, Fifth National Communications Symposium, Hotel Utica, Utica, N. Y. Oct. 5-7  
National Electronics Conference, sponsored by AIEE, IRE, Illinois Inst. of Tech., Northwestern Univ., and Univ. of Illinois, Sherman Hotel, Chicago, Ill. Oct. 12-14  
American Standards Association, Tenth National Conference on Standards, Sheraton-Cadillac Hotel, Detroit, Mich. Oct. 20-22

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167

## WHAT'S AVAILABLE IN REPRINTS

The following reprints have been prepared to make important reference-type editorial material available to CONTROL ENGINEERING readers in convenient fileable form. Some reprints are individual articles, while others are "packages"—several articles published over a period of time that logically supplement one another in the coverage of a specific phase of the control field. Any reprint can be obtained at the nominal cost listed below by filling in the order form and sending it, together with remittance, to Readers Service Dept. Quantity rates will be quoted on request.

**Fundamentals of Multivibrators**, 12 pp. Multivibrators are the electronic equivalent of the double-throw electromechanical relay and can perform substantially the same functions (memory, logic, gating, counting), but at enormously higher speeds. They can be built around vacuum tubes, transistors, square-loop magnetic materials, neon tubes, thyatrons, cryotrons, and other well-known components. This reprint covers a broad selection of multivibrator circuits that are especially applicable to control systems. 45 cents.

**A Roundup of Control System Test Equipment**, 24 pp. Specialized control system test equipment divides into three classes: 1) devices that only generate a test signal, 2) systems that both disturb the system and provide a means for evaluating response, and 3) devices that only evaluate control system response. Here's a survey of this equipment and tips on how to use it. 60 cents.

**Survey of Ac Adjustable-Speed Drive Systems**, June 1959, 16 pp. Largely regarded as constant-speed devices, multi-

Continued on page 170

### Reprint Order Form

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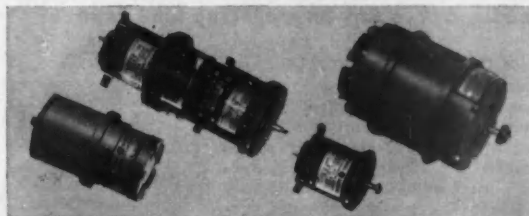
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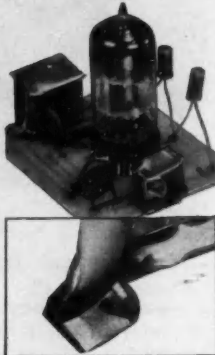
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**Fundamentals of Tie-Motor Control**, 12 pp. Although high-powered synchro-tie systems have been around for a long time, only recently has enough experience been logged to put their design on a scientific, rather than cut-and-try, basis. This reprint examines the types of motors that can be used in the light of the application characteristics, and considers the special circuit designs that are required. 30 cents.

**Applying Phase-Plane Techniques to Nonlinear System Design**, 16 pp. This series of three articles is designed to teach the use of phase-plane techniques to working system designers, on a practical rather than theoretical basis. It tells how to construct a phase-plane plot, how to interpret a plot in terms of system performance, and how to synthesize nonlinear systems using phase-plane techniques. 50 cents.

**Economics in Control**, December 1958, 24 pp. A special report covering the economic aspects of modernizing with control systems. It starts off with a guide to the financial factors of modernization, then tells the control engineer how to spot opportunities where the addition of instrumentation and control equipment will earn money, and concludes with nine case histories showing specific benefits of modernizing with control systems. 50 cents.

**First-Hand Report on Control Inside Russia**, November 1958, 16 pp. A team of 14 U. S. control engineers representing the American Automatic Control Council reports on the status of automatic control in Russia. Each expert gives impressions of progress in his field of interest based on visits to Russian user plants and research facilities. 40 cents.

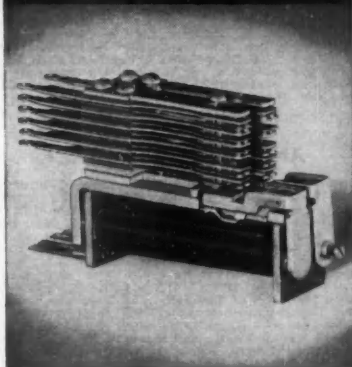
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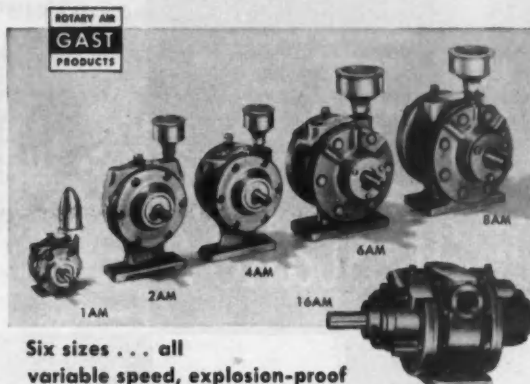
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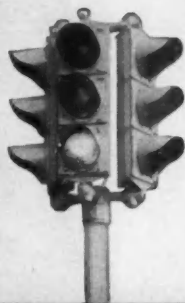
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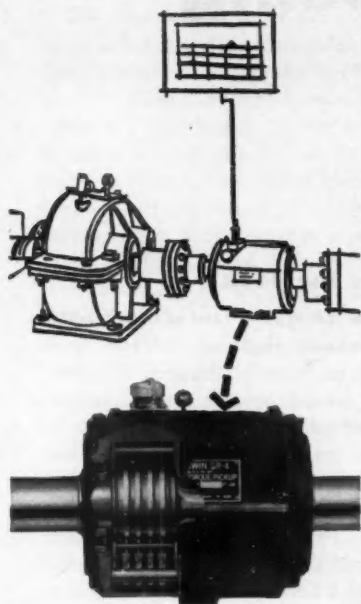
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## "Trade Follows The Book"

Books are in the advance guard of the Soviet political and economic challenge to the free world. With books go ways of thinking — about government, about education, about management, about science and technology. If these books do their job effectively in the training of those who will become a nation's leaders, they will provide the basis for political and cultural understanding and also, in the future, for trade.

The Russians are not the first to discover this relationship. Britain, which lives by trade, has traditionally exported more of its book production than any other nation. Today it exports one book in every two produced. The British have a favorite dictum: "Trade follows the book." They have proved its accuracy. Now the Russians are trying to make this same principle serve their purposes.

Where does the United States stand in this competition for men's minds? In number of books, it trails far behind the Soviet Union — exporting roughly 20 million books, against the Russians' 30 million. As a proportion of our total output of books, our exports amount to only 10% — against Britain's 50%.

## The Russians' Advantage

U.S. book exports have grown in the years since World War II, from approximately \$11,000,000 in 1946 to \$35,000,000 in 1958 (both figures excluding Canada). But in expanding book exports, the American publishing industry faces two major obstacles:

(1) **The comparatively high cost of producing a book in the United States**, which puts its price well beyond the reach of many students, teachers and businessmen in other countries; and

(2) **The shortage of dollar exchange in many countries**, which means that importers can pay for

books only in currencies that are of little use to American publishers.

The Russians have neither of these problems. Soviet publishing is state-subsidized, and exported books are sold for nominal sums paid in the currencies of the importers. As these books serve the political and economic purposes of the Soviet Union, they are cheerfully sold on giveaway terms.

**The American publishing industry, on its own, is making vigorous efforts to increase the distribution of American books in other countries.** Leading U.S. publishers and their agents have offices and salesmen in the major countries of Asia, Africa and Latin America. Several publishers have begun to reprint textbooks in Asia at one-half to one-third of their U.S. costs, thus making them available to the students in Asian countries at prices they can more nearly afford. And the American paperback has become a symbol of low cost in popular books. But neither of these devices is practicable for serious cultural, technical, scientific, educational and professional books, which require durable, hard-bound and necessarily expensive editions. Despite their great importance to those who need these books, the demand for them is simply not large enough to warrant low-cost publishing methods.

Government agencies also have increased the availability of American books. The United States Information Agency and the International Cooperation Administration have placed American books in libraries overseas, donated them to educational institutions and presented them to key individuals in the industries and governments of the developing countries of the world. But these programs are small in relation to the need.

### **A Modest Program**

**An unusual and little-publicized Government program has helped American publishers overcome the other major obstacle to the export of books — the shortage of dollar exchange.** This is the Informational Media Guaranty (IMG) program, administered by the United States Information Agency. It enables publishers of books judged to be worthy of the American way of life to sell their books, for local currency, in countries such as the Philippines, Formosa, Vietnam, Burma, Indonesia, Pakistan, Turkey, Israel, Poland, Yugoslavia, Spain and Chile, which would otherwise be unable to buy these books because of their shortage of U.S. dollar exchange.

**The IMG program is not a giveaway.** Publishers have to sell their books, and customers overseas have to want them enough to buy them at full prices. IMG merely guarantees that the exporting publisher receives in dollars the payments he collects from his customers in their currency. The program costs very little in

terms of our total foreign aid program, or in terms of what it accomplishes. In ten years it has made possible the sale of \$150 million worth of books, magazines and films to countries of key economic and strategic importance at a cost of only \$10 million.

The IMG functions through a revolving fund. Foreign currencies are exchanged for dollars, and the foreign currencies in turn are resold to replenish the supply of dollars. The net cost is the small but unavoidable loss on resale of these foreign currencies. Over the ten years of this program, the IMG revolving fund has shrunk from its original \$28 million to \$18 million, \$10 million of which is in unconverted foreign currencies.

**If this modest but vitally important program is to be continued, Congress must appropriate the money necessary to rebuild the revolving fund.** This would ensure that any country approved by the State Department and willing to sign an agreement to buy American books, at their full price, with its own currency, could do so. Last August, Congress reduced a requested appropriation for this purpose from \$7 million to \$2½ million. To continue even at its present reduced level, an appropriation of \$3½ million is needed. To realize the full potential of IMG, the revolving fund must be restored to its original level.

If the IMG program is not continued, with adequate financial support, some countries whose friendship and understanding we seek today and with whom we hope to build a trading partnership in the future will have to reduce their purchases of American books to a trickle. These are countries where school teachers, college professors, students, engineers, doctors and businessmen need and want to buy American books. The loss will be not only theirs, but ours as well. For it will deprive the U.S. of one of its most effective, and least costly, means of communicating knowledge and ideas and understanding of the American way of life.

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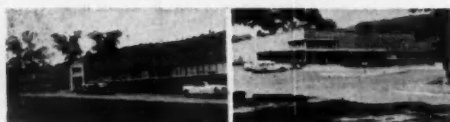
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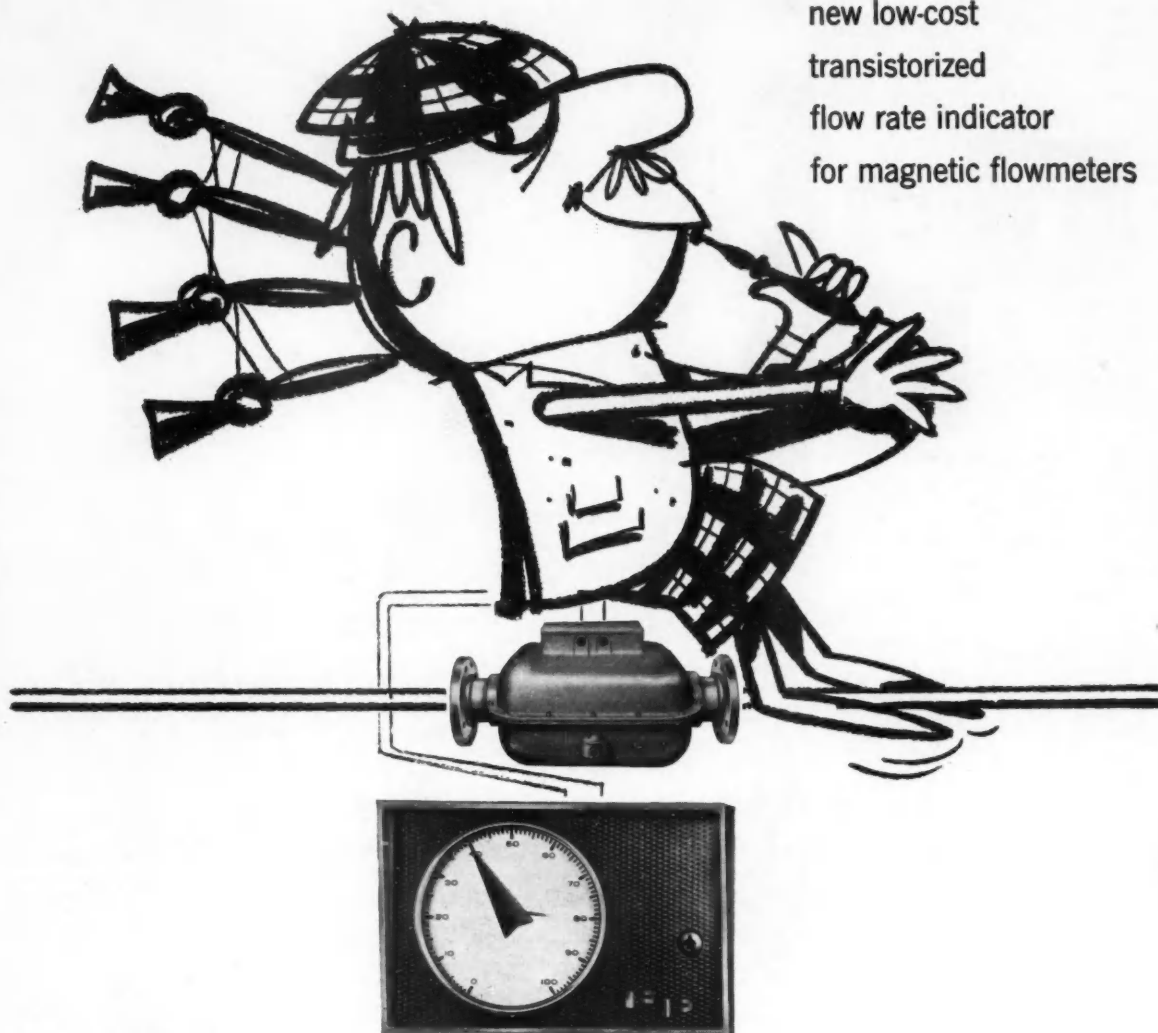
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